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Investigating possible movements of waterbirds between the Medway Estuary & Marshes SPA and neighbouring areas of the Thames and Swale Estuaries

Part 1

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EXECUTIVE SUMMARY

1. Wetland Bird Survey (WeBS) Core Count data were analysed to examine possible movements of waterbirds between the Medway Estuary & Marshes SPA and neighbouring estuaries, as a potential explanation for species declines on the Medway.

2. For those species identified to be of concern, detailed sector plot analyses were undertaken, where trends on particular WeBS sectors were compared to highlight potential movements.

3. Low Tide Counts collected as part of the WeBS scheme were compared with Core Counts, to ascertain whether the trends of feeding and roosting birds had changed over time and therefore determine whether birds may have still been using the Medway for feeding whilst roosting elsewhere.

4. Declines within the period from 1993/94 to 2003/04 were recorded for 11 species: Great Crested Grebe, Dark-bellied Brent Goose, Shelduck, Pintail, Oystercatcher, Ringed Plover, Grey Plover, Dunlin, Black-tailed Godwit, Curlew and Redshank. 'High Alerts' (declines >50%) were identified over the 10-year period from 1993/94 to 2003/04 for six species, with a further three 'Medium Alerts' (25-49% decline) over the same duration. Over the most recent 5-year period, 10 Medium Alerts were identified.

5. Trends in numbers on the Medway were considered in relation to those in the local area (the Medway, Thames and Swale Estuaries) and region (the Environment Agency watershed regions of Southern and Anglia) to determine if they differed. Two species, Ringed Plover and Dunlin, appeared to hold declining proportions of the regional and local populations, implying that rates of change were more rapid on the Medway than the comparative wider scale site complexes. Other declines appeared broadly consistent with regional and / or local trends.

6. Sector plot analyses showed that the greatest declines within the Medway had occurred on WeBS sector #22967, Hoo, Nor, Bishop and Copperhouse Marshes.

7. Clear movements from the Medway to either the Swale or Thames Estuaries were not apparent over the analysis period for any species. However, for six species of wader (Oystercatcher, Ringed Plover, Grey Plover, Dunlin, Curlew and Redshank) trends on sectors suggested the possibility that some birds may have moved to neighbouring sites.

8. Ringed Plover and Dunlin exhibited the strongest evidence for local redistribution to the Thames and Swale.

9. Of the 11 species identified to be in decline by Core Count data, eight also showed declines in their Low Tide Count trends, indicating that the factors leading to declines have similarly affected both roosting and feeding usage of the site.

10. Sector plot analyses do not reveal what initiated declines and induced any possible between-site movements. Potential reasons for the declines in waterbird numbers on the Medway Estuary are therefore also discussed.

1. INTRODUCTION

The Wetland Bird Survey (WeBS) 'Alerts' system aims to illustrate those Special Protection Areas (SPAs) experiencing declines in wintering waterbirds, to focus attention for conservation. Recent analysis of waterbird trends under the Alerts system has highlighted the Medway Estuary & Marshes SPA as a site of serious concern (Austin *et al.* 2004). Of 15 waterbird species analysed for the SPA, 13 had experienced recent declines. Using standard WeBS Alerts calculations (Leech *et al.* 2002), 'High Alerts' (>50% decline) were triggered for nine species, and 'Medium Alerts' (25% - 49.9% decline) for a further four species, over specified time periods up to the winter of 1999/2000. The majority of declines occurred within the 10-year period from 1989/90 to 1999/2000.

A list of species examined, with those undergoing notable declines listed, appears below (from Austin *et al.* 2004). Superscripts indicate the time period over which Alerts were triggered; parenthesised figures indicate that caution should be applied in interpreting declines, as changes of the size noted may occur as part of natural fluctuations for the species over the specified time periods.

15 Evaluated Species: Little Grebe *Tachybaptus ruficollis*, Great Crested Grebe *Podiceps cristatus*, Cormorant *Phalacrocorax carbo*, Dark-bellied Brent Goose *Branta bernicla bernicla*, Shelduck *Tadorna tadorna*, Wigeon *Anas penelope*, Teal *A. crecca*, Pintail *A. acuta*, Oystercatcher *Haematopus ostralegus*, Avocet *Recurvirostra avosetta*, Ringed Plover *Charadrius hiaticula*, Grey Plover *Pluvialis squatarola*, Dunlin *Calidris alpina*, Curlew *Numenius arquata*, Redshank *Tringa totanus*

High Alert: Little Grebe[5,10], Great Crested Grebe[10], Shelduck[10], Wigeon[10,25], Teal[Max], Pintail[25], Ringed Plover[5], Dunlin[5], Redshank[5]

Medium Alert: Great Crested Grebe[5], Cormorant[10], Dark-bellied Brent Goose[5,10], Shelduck[(5)], Teal[(10)], Pintail[(10)], Grey Plover[5], Dunlin[25], Curlew[(5),25], Redshank[25]

5 – 5-year period from 1994/95 to 1999/2000
10 – 10-year period from 1989/90 to 1999/2000
25 – 25-year period from 1974/75 to 1999/2000
Max – whole reporting period up to 1999/2000

Of these declining species, seven are of international importance on the Medway: Dark-bellied Brent Goose, Shelduck, Pintail, Ringed Plover, Grey Plover, Dunlin and Redshank.

One suggested cause of the declines recorded on the Medway is that birds may have relocated to other wetland sites nearby, such as the Thames and Swale Estuaries. To investigate such possible movements this report focuses on changes on individual WeBS Core Count sectors (Core Counts generally record birds at roost, when tides are high and feeding areas are inundated). By analysing changes on sectors of the Thames and Swale Estuaries, it should be possible to infer whether the declines recorded in roosting bird numbers on the Medway were coincident with increases on particular neighbouring sites. This may be particularly pertinent for areas such as Elmley Marshes, an area of 3,300 acres of rough, damp grazing pasture and saltmarsh by the Swale Estuary, managed to enhance the habitat for waterbirds by RSPB and Elmley Conservation Trust since 1975. A method recently developed for use in WeBS Alerts analysis allows estimation of the proportion of birds held by a site in comparison to the local area and / or region (Banks & Austin 2004). This technique can be applied to discover whether an SPA has increased or decreased in terms of the local number of birds held, and thus learn whether wider species trends can explain declines at the SPA level.

It is difficult to ascertain, though, whether the declines recorded in the numbers of waterbirds using the Medway Estuary at high tide also reflect declines in the numbers of birds using the estuary for feeding during the low tide period. The numbers of each species using the SPA at high and low tide are therefore also compared in this report so as to determine whether some of the birds that use the estuary for feeding during the low tide period might now leave it to roost elsewhere over high tide.

The report thus has three main aims:

(i) To compare waterbird trends on the Medway Estuary & Marshes SPA over the most recent 10-year period to those in the region as a whole and also the local area including the Thames and Swale Estuaries.
(ii) To investigate trends on sectors of the Medway, Thames and Swale Estuaries to identify areas where relocation of species shown to be in decline on the Medway Estuary & Marshes SPA may have occurred.
(iii) To compare high and low tide counts on the Medway Estuary & Marshes SPA to investigate changes in proportions of roosting to feeding birds over time.

2. METHODS

2.1 Wetland Bird Survey Data

All data used in this report were collected as part of the Wetland Bird Survey (WeBS).

Trends in species numbers were derived from data collected as part of the WeBS Core Count scheme. On the coast, these counts are typically undertaken at high tide when birds are roosting. Data from the 10-year period 1993/94 to 2003/04 (the most up-to-date counts available) were analysed (i.e. the period during which the majority of declines had been recorded on the Medway).

WeBS Low Tide data for the Medway were collected in the winter of 1996/97 and again in the winter of 2004/05. These counts provide information on the distribution and numbers of birds feeding within the estuary.

2.2 Waterbird Trends and Alerts Methods

WeBS Core Count data were analysed to produce plots of smoothed trends for the period from 1993/94 to 2003/04 for all of the species for which the Medway Estuary and Marshes SPA (referred to hereafter as the Medway Estuary or the Medway) is designated (Stroud *et al.* 2001; see section 2.2.1) with the exception of Lapwing *Vanellus vanellus* (see Austin *et al.* 2004). The resultant plots were then used to update the percentage change figures and Alerts data provided in Austin *et al.* (2004).

Species trends on the Medway were compared to those in the 'region' as a whole (*i.e.* the Environment Agency watershed regions of Southern and Anglia) and the 'local area' comprised by the Medway, The Swale SPA (referred to hereafter as the Swale Estuary or the Swale) and the outer part of the Thames Estuary and Marshes SPA (referred to hereafter as the Thames Estuary or Thames) (see section 2.2.3). For the purposes of this report, the latter area comprised the North Kent Marshes and the shore from Mucking to Southend.

In addition, waterbird trends were also calculated for all 16 species for each of the 13 WeBS Core Count sectors of the Medway, the six sectors of the Swale and 16 sectors of the Thames.

Full details pertaining to the use of Generalized Additive Models (GAMs; Hastie & Tibshirani 1990) for the calculation of annual waterbird indices and the fitting of smoothed trend curves (*e.g.* by the WeBS Alert System) are available elsewhere (Atkinson *et al.* 2001; Leech *et al.* 2002). An overview is given here.

2.2.1 Annual averages

The figures used to plot waterbird trends are based on the average annual value for a particular winter. This is calculated as the number of birds present in that winter (summed monthly counts across all sectors counted) divided by the number of months counted. The months selected for analysis are based on those for which numbers of the species are considered to be most stable (*i.e.* avoiding passage movements), used as standard by WeBS (*e.g.* Austin *et al.* 2004) and tabulated below for the 16 species considered in this report (Table 2.2.1).

Inevitably, some site / year and sector / month combinations have missing counts. Where count data are not available, it is necessary to impute data to provide a complete trend. At the site level (*i.e.* the Medway Estuary), missing counts are imputed using the Underhill method (Underhill & Prŷs-Jones 1994). This method uses a Generalized Linear Model (GLM) with month, year and site factors. The site factor in this instance relates to those sites within the relevant Environment Agency water catchment areas named Southern and Anglian.

Sector level imputation uses a different method, based on the expected proportion of birds a sector held in relation to counts made on the same date across the whole site (*e.g.* the Medway Estuary). The proportions of the site totals held by the sector on each of the 15 temporally proximate counts (within a three month restriction window) are calculated, then averaged. Therefore the average proportion can be multiplied by the site-level total to provide an estimated value for the missing count on the sector.

Species	Code	Index months (GB)
Little Grebe (*Tachybaptus ruficollis*)	LG	SO
Great Crested Grebe (*Podiceps cristatus*)	GG	SON
Cormorant (*Phalacrocorax carbo*)	CA	SONDJFM
Dark-bellied Brent Goose (*Branta bernicla b.*)	DB	DJF
Shelduck (*Tadorna tadorna*)	SU	JF
Wigeon (*Anas penelope*)	WN	J
Teal (*Anas crecca*)	T.	D
Pintail (*Anas acuta*)	PT	ONDJ
Oystercatcher (*Haematopus ostralegus*)	OC	DJF
Avocet (*Recurvirostra avosetta*)	AV	DJF
Ringed Plover (*Charadrius hiaticula*)	RP	DJF
Grey Plover (*Pluvialis squatarola*)	GV	DJF
Dunlin (*Calidris alpina*)	DN	DJF
Black-tailed Godwit (*Limosa limosa*)	BW	DJF
Curlew (*Numenius arquata*)	CU	DJF
Redshank (*Tringa totanus*)	RK	DJF

Table 2.2.1 Standard indexing months used in WeBS analyses (*e.g.* Austin *et al.* 2004) for the 16 predominant species recorded on the Medway Estuary & Marshes SPA.

2.2.2 Smoothed GAM trends

Natural temporary fluctuations in numbers, for example those caused by variation in the severity of conditions over the winter period, can differ in size and / or direction from longer-term trends, hindering their interpretation. Extreme values may trigger false 'Alerts' (i.e. >25% declines using WeBS methodology) due to misinterpretation of temporary, short-term declines as longer-term trends. Alternatively, long-term trends that may have led to Alerts being flagged could be obscured by short-term fluctuations. In order to avoid such misinterpretations and misidentifications when calculating Alerts, the Alerts System uses GAMs to fit a smoothed trend curve to the annual indices, and this technique is adopted here. This is done by reducing the number of degrees of freedom available to the GAMs. As the number of degrees of freedom is decreased from (n-1) the trend becomes increasingly smooth until ultimately with one degree of freedom the smoothed curve becomes a linear fit. The WeBS Alert System adopts a standard (n/3) degrees of freedom to produce a level of smoothing that, while removing temporary fluctuations not likely to be representative of long term trends capture those aspects of the trends that may be considered to be important.

Changes in numbers calculated using values from a smoothed GAM trend are less likely to be due to the effects of temporary fluctuations in numbers, or to errors when sampling, than results produced were annual index values to be used. Thus, using GAMs reduces the probability that a decline from a short-lived unsustainable peak in numbers would be misinterpreted as a noteworthy decline.

2.2.3 Regional and local comparisons

To compare trends at the site level (*i.e.* the Medway Estuary & Marshes SPA) with those for the same species at wider spatial scales, additional statistical procedures recently developed for WeBS Alerts were employed (Banks & Austin 2004). Generalized Linear Models (GLMs; McCullagh & Nelder

1989) were used to assess the relative proportion of the 'complex' total (*i.e*. the 'local area', which includes the Medway, Thames and Swale Estuaries) held by the target consolidation (*i.e*. the Medway Estuary & Marshes SPA). This procedure was also used to investigate the proportion of the regional totals supported by the site (*i.e.* the Environment Agency watershed regions of Southern and Anglia).

The proportion, *i.e*. the number of birds counted at the Medway Estuary per year divided by the total for each complex or region for the year, was modelled by logistic regression. The models were binomial and specified a logit link function (logit(p) = log(p/1-p)), to ensure valid probability estimates in the range [0,1]. Count values were only included in analysis where coverage was complete. Counts flagged as 'poor quality' were not included for analysis.

Output plots were generated for each species to show how the proportion of the local area or region's birds occurring on the Medway varied across years. The 95% confidence limits obtained represent the confidence in the calculation of the predicted proportion as it varies with the total number of birds in the complex or region, and the between-month variation in the average proportion a site holds in a given winter.

Changes in waterbird numbers are reflected in three possible proportional trends; positive, negative and stable.

Where numbers on a site undergo expansion, and regional trends decline or remain stable, a proportional increase is seen at the site under review. The trend is for estimates to increase with time, with largely non-overlapping confidence limits.

Negative trends in the proportional estimate suggest one of three scenarios, and consideration of species' regional and site trends can determine which applies. Firstly, the site trend could be in decline while the regional trend increases or remains stable. Thus the proportion at the site becomes smaller as the two trends diverge. Secondly, the site trend could be stable whilst the regional trend increases. Thirdly, both trends may increase or decline, but at different rates. If regional counts were formerly low, a particular site may have held a relatively high proportion of the regional total. If the species in question then expands in number across the region but remains stable at the site, the relative proportion at the site will decrease.

Plots can also be produced that suggest a species is relatively stable in numbers in comparison to the region, typically where a horizontal line can be drawn between the ranges of all confidence limits. These plots do not signify in which direction the site and regional trends are heading (i.e. increasing, decreasing or stable), merely that they remain consistent with each other.

2.3 Core Counts vs. Low Tide Counts

Changes in WeBS Low Tide Counts of waterbirds on the Medway Estuary between the winters of 1996/97 and 2004/05 were investigated using a Generalized Linear Model, relating numbers of birds to count section, month and year factors. Models assumed a Poisson distribution for the number of feeding birds, specified a log link function and treated the natural logarithm of mudflat area (ha) as an offset. Independent variables were treated as class variables. The problem of overdispersion caused by a combination of a large number of zero counts with several very high counts, typical of flocking species, was addressed by the application of a scale factor estimated from the square root of the Pearson's Chi-squared statistic divided by its degrees of freedom.

The results of the models were used to create a simple index of low tide numbers on the Medway, with the value for winter 2004/05 set to equal one. For each species, this index was plotted on a graph with the trend for the Medway calculated using WeBS Core Count (high tide) data. Any differences in the Low Tide Count and Core Count trends would indicate that the ratio of feeding to roosting birds had changed over the time period of analysis.

3. RESULTS

3.1 Waterbird Trends on the Medway Estuary & Marshes SPA

Table 3.1.1 shows percentage change figures for each species on the Medway over the 5-period from 1993/94 to 1998/99 and the 10-year period from 1993/94 to 2003/04. Updated Alerts were triggered for 11 species: Great Crested Grebe, Dark-bellied Brent Goose, Shelduck, Pintail, Oystercatcher, Ringed Plover, Grey Plover, Dunlin, Black-tailed Godwit, Curlew and Redshank.

Species	5-year Alert	10-year Alert	5-year trend	10-year trend
LG	++	++	55.56	55.56
GG	-	-	-26.09	-35.85
CA	o	o	-2.47	12.06
DB	-	--	-42.23	-63.93
SU	(-)	--	-40.58	-62.87
WN	o	o	-23.37	1.94
T.	o	o	-24.57	-17.92
PT	(-)	(-)	-45.41	-45.00
OC	-	o	-42.68	-19.56
AV	++	++	51.06	115.15
RP	(-)	--	-38.84	-60.47
GV	-	--	-48.22	-53.45
DN	(-)	--	-27.02	-61.93
BW	-	o	-36.36	-20.33
CU	(-)	-	-34.02	-48.60
RK	(-)	--	-32.12	-51.19

Table 3.1.1 Percentage change and Alerts for waterbirds at the Medway Estuary & Marshes SPA over the 5-period from 1993/94 to 1998/99 and the 10-year period from 1993/94 to 2003/04. Medium Alert indicated by -; High Alert indicated by --; High Increase indicated by ++; No substantial change indicated by o. Where a figure is bracketed, this Alert should be treated with caution, as the change may be within the species' 'normal' range of fluctuation (Austin *et al*. 2004).

3.1.1 Little Grebe

Little Grebe numbers on the Medway over the last ten years have remained largely stable (Figure 3.1.1a), with the exception of large counts in 1995/96, 2001/02 and 2002/03, which contribute to a large overall increase during the period of analysis (Figure 3.1.1a, Table 3.1.1). The Alerts triggered in Austin *et al.* (2004) were over the 5- and 10-year periods up to the winter of 1999/00, but the recent high counts in 2001/02 and 2002/03 appear to have negated the declines previously identified. Therefore this species is not considered to be of current concern and detailed sector plot analysis was not deemed necessary.

3.1.2 Great Crested Grebe

In contrast to the Little Grebe, Great Crested Grebes have declined shallowly in number on the Medway over the period analysed, triggering Medium Alerts for the 5-year period (1998/99-2003/04) and the 10-year period (1993/94-2003/04) (Figure 3.1.2a, Table 3.1.1). One very large count in 1995/96 may have influenced this result slightly, but it appears that the negative trend has continued since 1998/99. Although the proportion of local area Great Crested Grebes has remained consistently high (Figure 3.1.2c), this species is considered further for sector plot analysis as there have been recent regional and national increases (Austin *et al*. 2004).

3.1.3 Cormorant

Cormorant numbers appear to have remained stable on the Medway over the period of time analysed (Figure 3.1.3a, Table 3.1.1). The winter average has remained above 100 and rarely deviated far enough to reflect a positive or negative pattern. Although Austin *et al.* (2004) reported declines over the period 1989/90 to 1999/2000, this trend has not continued; high counts in the winters of 1989/90 and 1990/91, against an otherwise stable trend, are likely to have triggered the aforementioned declines. It is possible that the numbers of Cormorants may be decreasing on other local estuaries, as the local proportion estimated to be supported on the Medway shows signs of increase (Figure 3.1.3c). This species is not considered further for detailed sector plot analysis.

3.1.4 Dark-bellied Brent Goose

Numbers of Dark-bellied Brent Geese wintering on the Medway have declined steadily since the peak recorded in 1993/94 (Figure 3.1.4a). A similar, though shallower, trend seems to have occurred in the region as a whole, and indeed across England up to 2000/01 (Austin *et al.* 2004). Over the current period of analysis, a High Alert was issued over the 10-year period, a Medium Alert over the 5-year period (Table 3.1.1). The proportional estimates of the numbers of Dark-bellied Brent Geese held by the Medway have remained fairly stable in comparison to both the wider region and the local area, supporting the idea that declines at the Medway are in step with those at other spatial scales (Figures 3.1.4b, 3.1.4c). This species is, however, of international importance on the Medway, and is considered further for sector plot analysis.

3.1.5 Shelduck

In common with Dark-bellied Brent Geese, Shelduck have also declined on the Medway in recent years, and at a comparable rate (Figure 3.1.5a). Similar patterns are evident for the area as a whole, raising the suggestion that this decline may be symptomatic of a wider species trend rather than local movement, though the local area comparison suggests that the Medway may be becoming of increasing local importance for Shelduck (Figure 3.1.5c). Similarly, until 1997/98, the Medway supported an estimated 10% of the regional total, at which point this proportion fell (Figure 3.1.5b). Although a Medium Alert was triggered for Shelduck for the 5-year period, this should be interpreted with caution, as according to the biological filter developed by Austin *et al.* (2004), this may be within acceptable levels of fluctuation for the species. However, a High Alert over the 10 years leading up to 2003/04 is of more concern (Table 3.1.1). This species is of international importance on the Medway and is considered further for sector plot analysis.

3.1.6 Wigeon

Wintering Wigeon on the Medway have undergone a fluctuation in numbers in the past 10 years, with peak numbers recorded in 1996/97 and a minimum in 2001/02. The overall GAM trend is, however, fairly smooth and no Alerts were triggered (Figure 3.1.6a, Table 3.1.1). The Alerts identified in Austin *et al.* (2004) seem to have been caused by fluctuations prior to 1993/94, and do not include the four years between 1999/00 and 2003/04. Longer-term declines since the mid-1980s (Austin *et al.* 2004) have showed little sign of reversal in the most recent ten years of analysis, but stability suggests declines have levelled off. Therefore this species is not considered to be of current concern and detailed sector plot analysis is not necessary.

3.1.7 Teal

Teal numbers have exhibited some fluctuation on the Medway, but not to the extent of Wigeon. The trend is very similar, however, with little change over the period of analysis (Figure 3.1.7a, Table 3.1.1). The estimated proportion of birds in the local area held by the Medway has perhaps shown a slight decline over the past two years (Figure 3.1.7c). However, this species is not considered to be of concern, as no Alerts were triggered, and detailed sector plot analysis is not necessary.

3.1.8 Pintail

Both the absolute numbers of Pintail on the Medway and the proportion of the local population held on the site increased between 1993/94 and 1995/96 (Figures 3.1.8a & 3.1.8c). Since this time there has been a sustained decline, with a notable drop-off in the winter of 2003/04 and Medium Alerts were issued over both 5- and 10-year periods (Figure 3.1.8a, Table 3.1.1). However, these Alerts should be interpreted with caution, as according to the biological filter developed by Austin *et al*. (2004), this may be within acceptable levels of fluctuation for the species. There is little evidence from the estimated proportions that the status of the species within the context of the region has altered (Figure 3.1.8b). This species is of international importance on the Medway and is considered for sector plot analysis.

3.1.9 Oystercatcher

Numbers of Oystercatcher rose to a peak within the 10-year period in 1998/99 and have since declined triggering a 5-year Medium Alert (Figure 3.1.9a, Table 3.1.1). The peak in the winter average led to a similarly short-lived increase in the proportion of the regional population held by the Medway (Figure 3.1.9b). The proportion of the local population of Oystercatcher supported by the Medway has fluctuated somewhat over the past ten years, but estimates are generally within the confidence limits of the comparative years of analysis, indicating a largely stable proportion. Due to the 5-year decline, however, this species is considered for further detailed sector plot analysis.

3.1.10 Avocet

At both the level of the SPA and the wider local area, Avocet numbers are increasing steadily, as on much of the southeast coast of Britain (Figure 3.1.10a, Table 3.1.1). Although declines have been recorded on the Medway in the past two count winters, the proportion supported on the site has not appreciably altered, as estimates for each winter are always within the confidence limits of the other winters analysed (Figure 3.1.10c). This species is not considered further for detailed sector plot analysis.

3.1.11 Ringed Plover

Numbers of Ringed Plover have shown a prolonged decline on the Medway Estuary (Figure 3.1.11a). To this end, a Medium Alert was fired over the 5-year period (although against the biological filter caveat of Austin *et al.* 2004), and a High Alert also issued over the 10- year period (Table 3.1.1). The proportion of the local population of birds held by the Medway is estimated to have declined accordingly (Figure 3.1.11c). This might indicate a shift in the local distribution of Ringed Plover, as if the entire local area population was declining at similar rates, the Medway would have retained the same proportion of local birds. This species is of international importance on the Medway and its decline is therefore of particular concern; it is thus considered further for sector plot analysis.

3.1.12 Grey Plover

Although this species has declined on the Medway Estuary (Figure 3.1.12a), declines are perhaps consistent with those in the local area, as the proportion of local birds held has remained largely the same (Figure 3.1.12c). However, the winter average has decreased from above 2,500 to below 1,500 over the period of analysis, and Alerts were triggered over both the 5- and 10-year periods (Table 3.1.1). This species is of international importance on the Medway and is considered for sector plot analysis.

3.1.13 Dunlin

There has been a steep and consistent decline in the numbers of over-wintering Dunlin on the Medway (Figure 3.1.13a). A cautionary Medium Alert was fired in the 5-year period leading up to 2003/04,

with a High Alert over the 10-year period (Table 3.1.1). The proportion of the regional population held by the Medway has dropped from the figure of around 10% in 1993/94 to an estimate of approximately 5% in 2003/04 (Figure 3.1.13b), whilst the proportion of the local population supported by the Medway Estuary has also declined steadily (Figure 3.1.13c), hinting that Dunlin may now roost somewhere else. However, the last two winters indicate this pattern may now be changing again, possibly with severe declines elsewhere in the local area boosting the relative importance of the Medway. This species is of international importance for the Medway and its decline is therefore of concern; it is thus further considered for sector plot analysis.

3.1.14 Black-tailed Godwit

Numbers of Black-tailed Godwit on the Medway showed peaks in 1995/96 and 1999/00 and the decline beginning just before the latter winter has triggered a 5-year Medium Alert (Figure 3.1.14a, Table 3.1.1). A similar pattern is particularly apparent when considering the proportion of the local population held by the Medway, though confidence limits are wide (Figure 3.1.14c). Due to this recent decline this species is considered in further detail in sector plot analysis.

3.1.15 Curlew

Curlew wintering on the Medway have undergone sizable and prolonged declines over the period of analysis, resulting in a (cautionary) Medium Alert over the 5-year period and a Medium Alert (49% decline) over the 10-year period (Figure 3.1.15a, Table 3.1.1). Although the estimated proportion of the regional and local population of Curlew supported by the Medway seems consistent (Figures 3.1.15b, 3.1.15c), this species is therefore considered further for sector plot analysis.

3.1.16 Redshank

Redshank have undergone a long-term decline in number on the Medway (Figure 3.1.16a), with the most pronounced decline from 1993/94 to 1995/96. As a result of this, a High Alert was triggered for the 10-year period (Table 3.1.1). The proportion of the regional population held by the Medway also dropped between 1993/94 and 1995/96 (Figure 3.1.6b), but at the same time, the proportion of the local population held by the Medway has remained high at around 50% (Figure 3.1.16c). This suggests that trends on the Thames and Swale Estuaries are likely to be reflective of the Medway. As the species is internationally important on the Medway and has declined over the 10-year period of analysis, it is considered further for sector plot analysis.

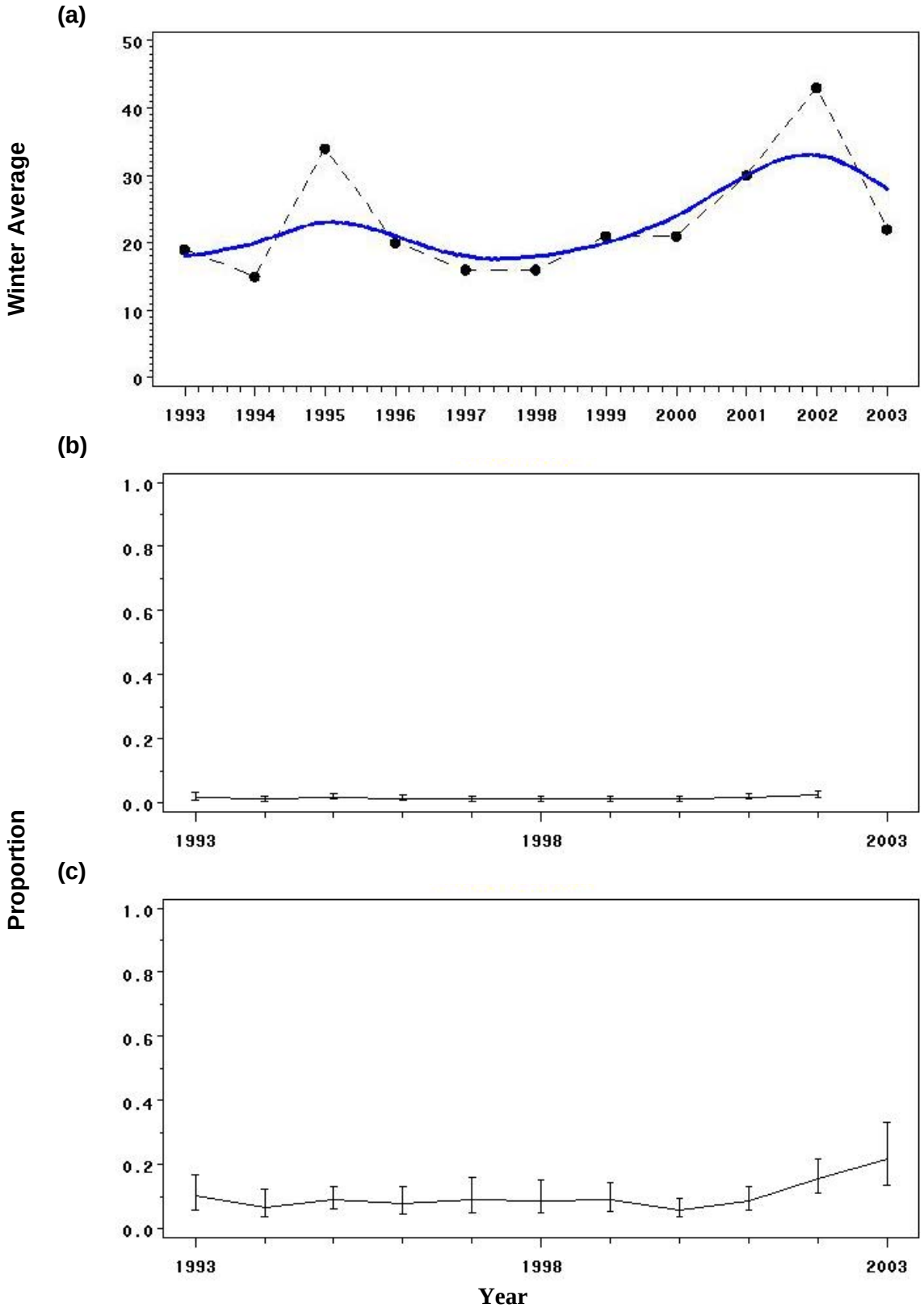


Figure 3.1.1 Little Grebe (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

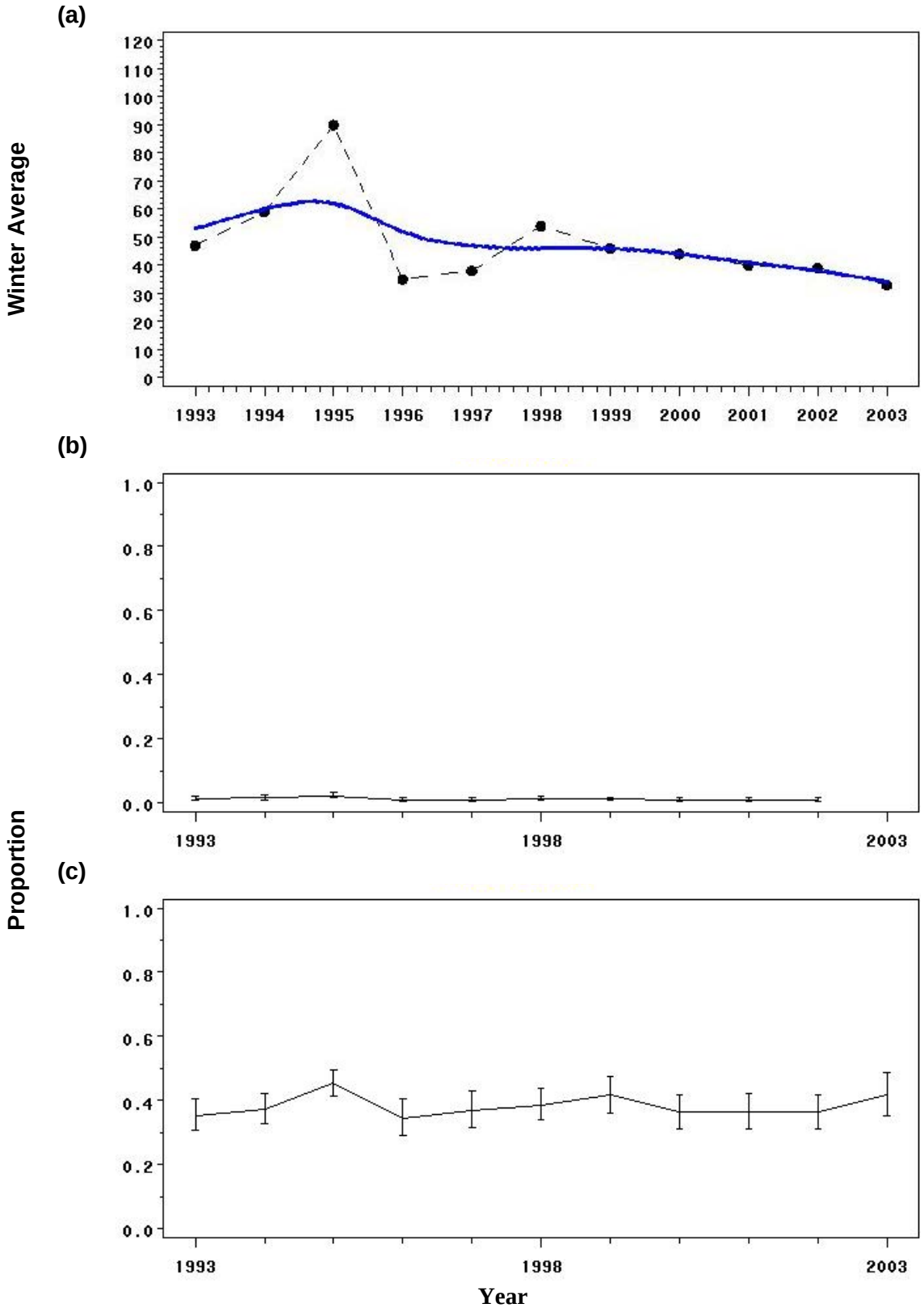


Figure 3.1.2 Great Crested Grebe (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

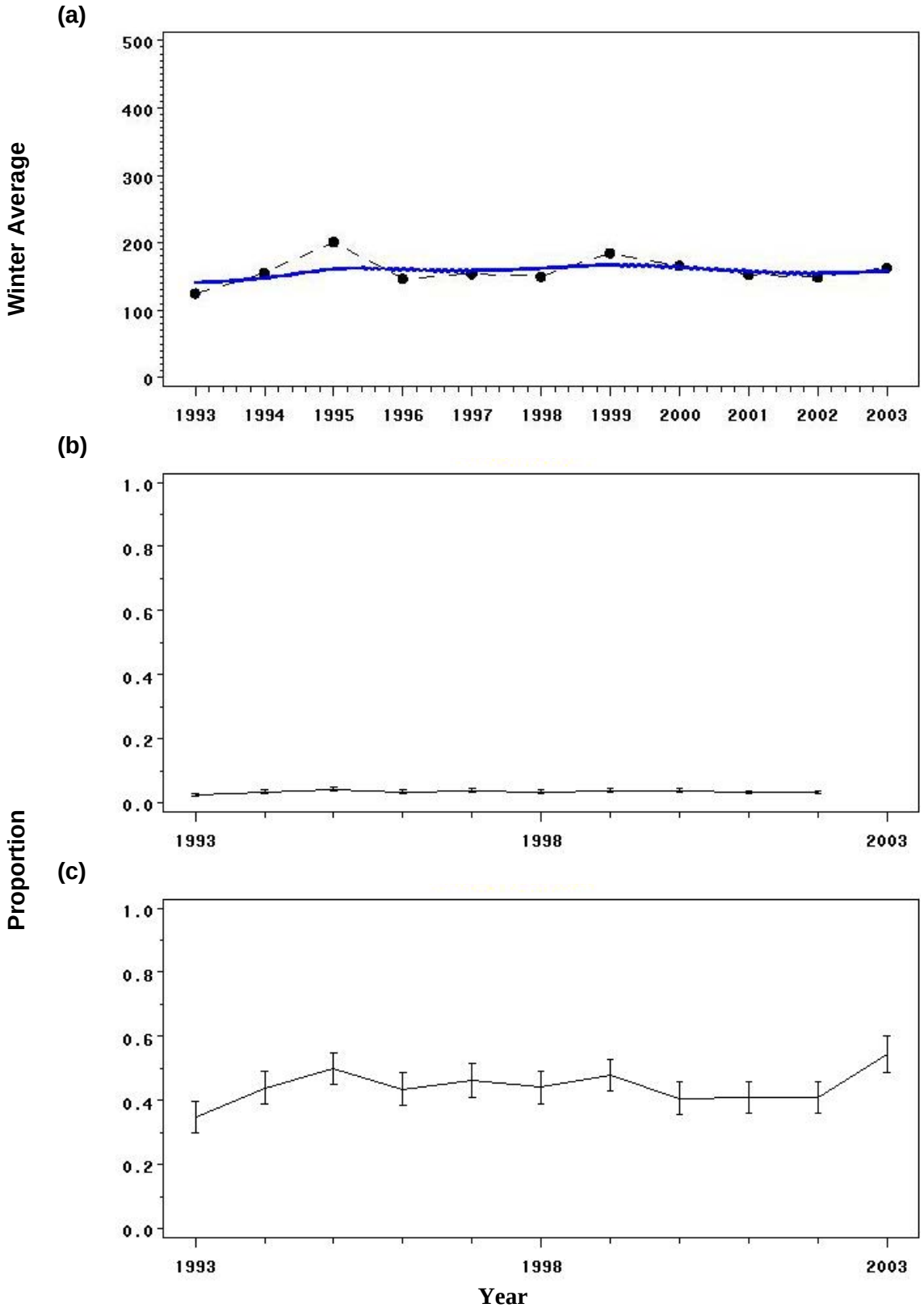


Figure 3.1.3 Cormorant (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

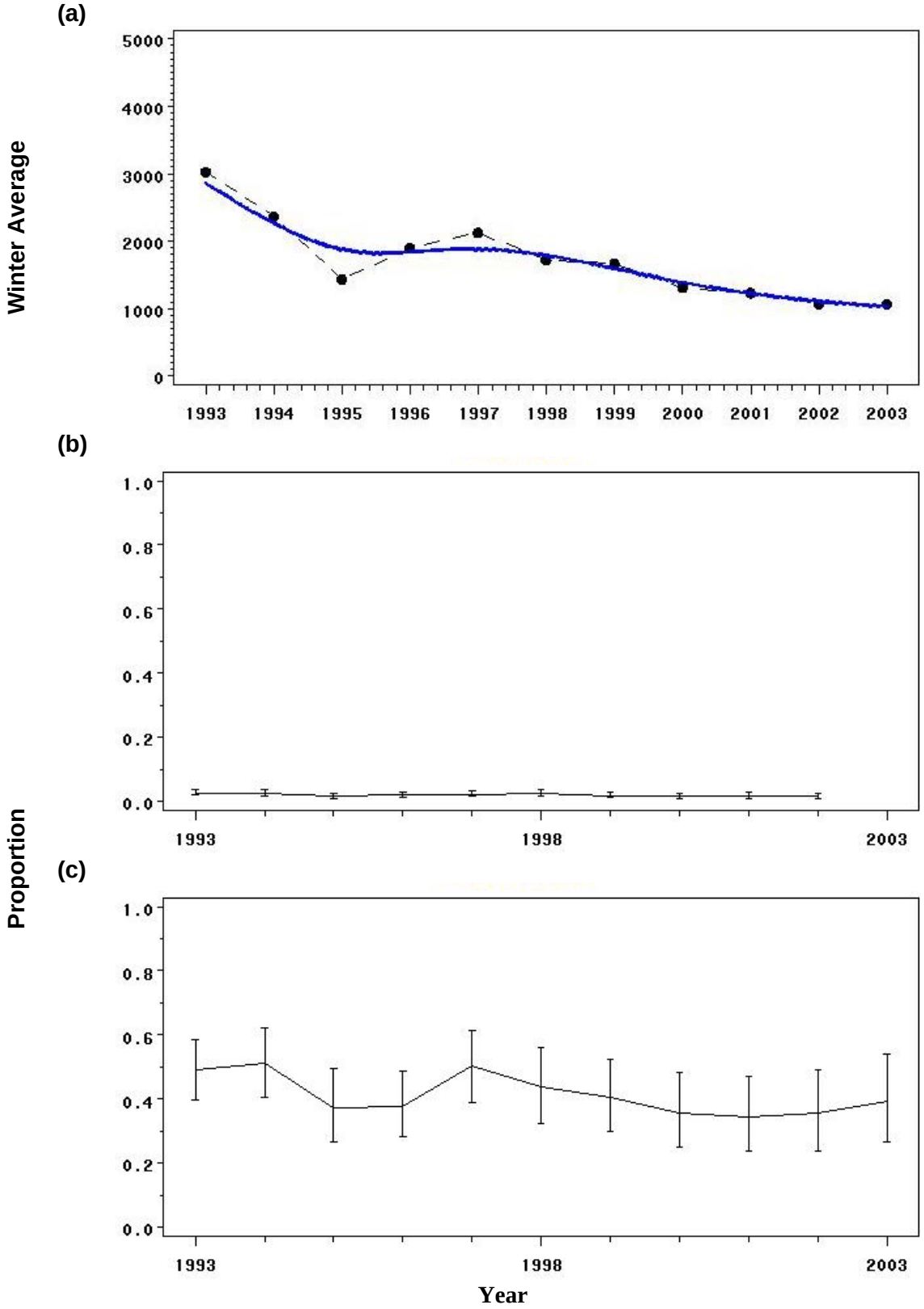


Figure 3.1.4 Dark-bellied Brent Goose (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

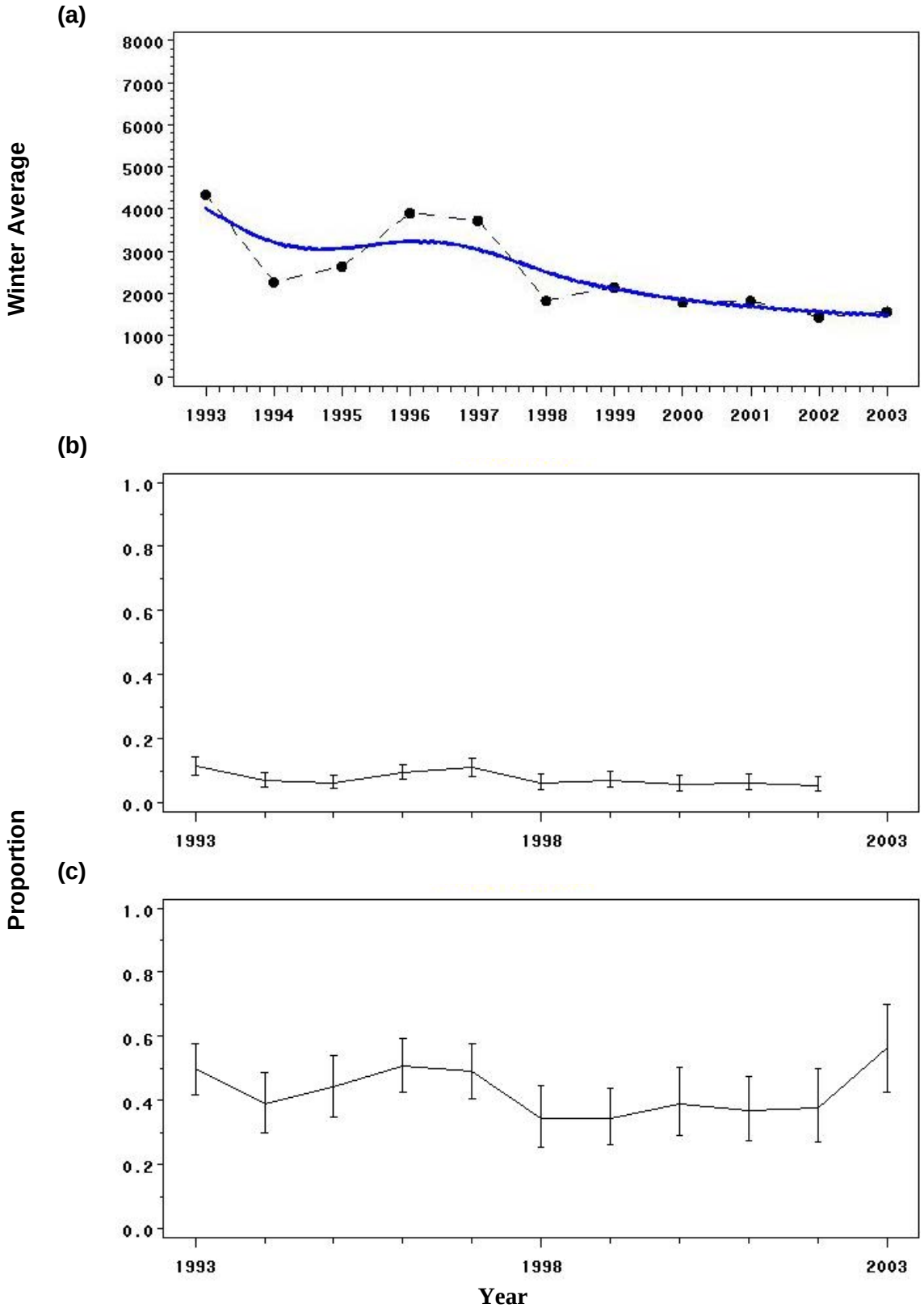


Figure 3.1.5 Shelduck (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

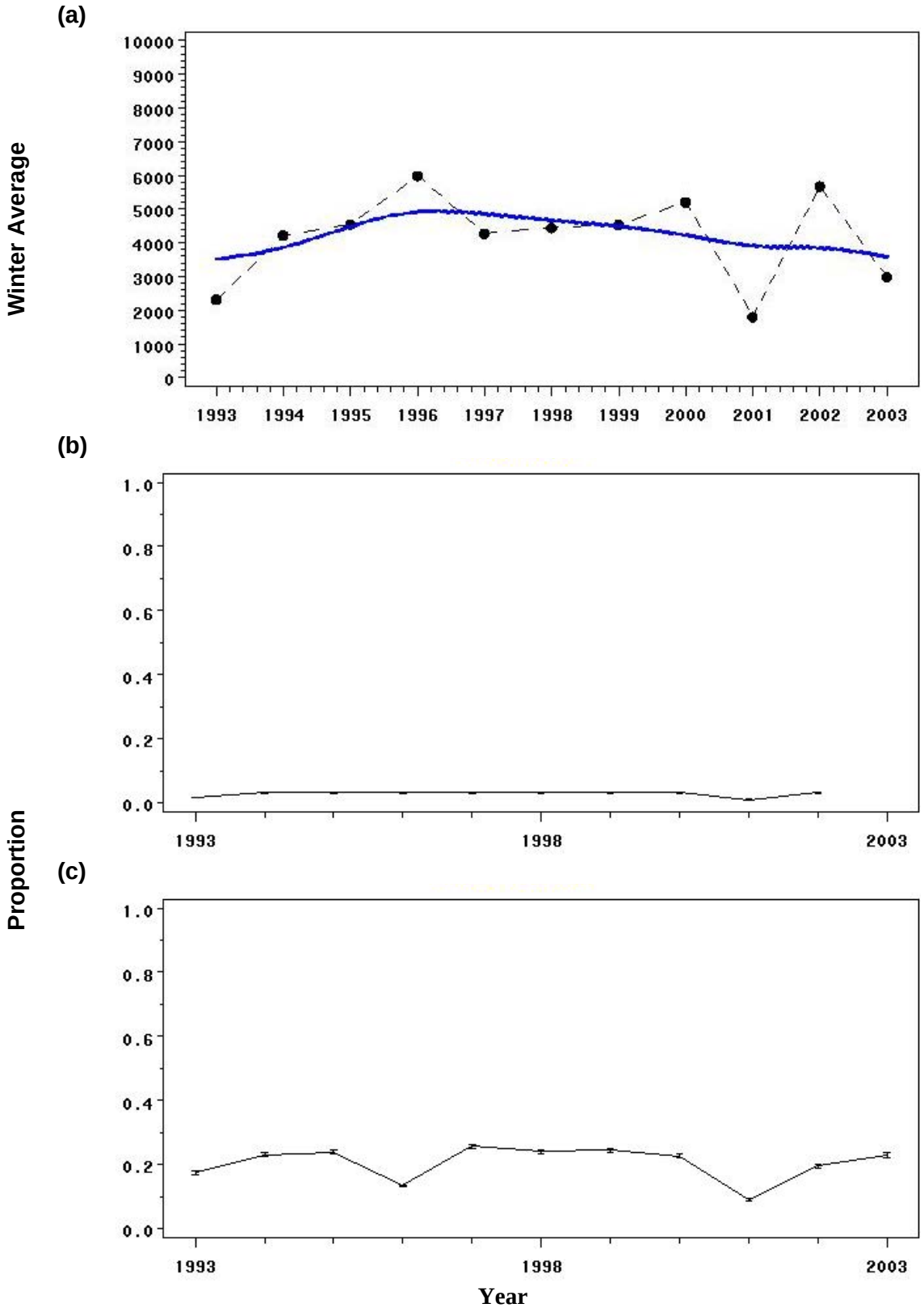


Figure 3.1.6 Wigeon (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

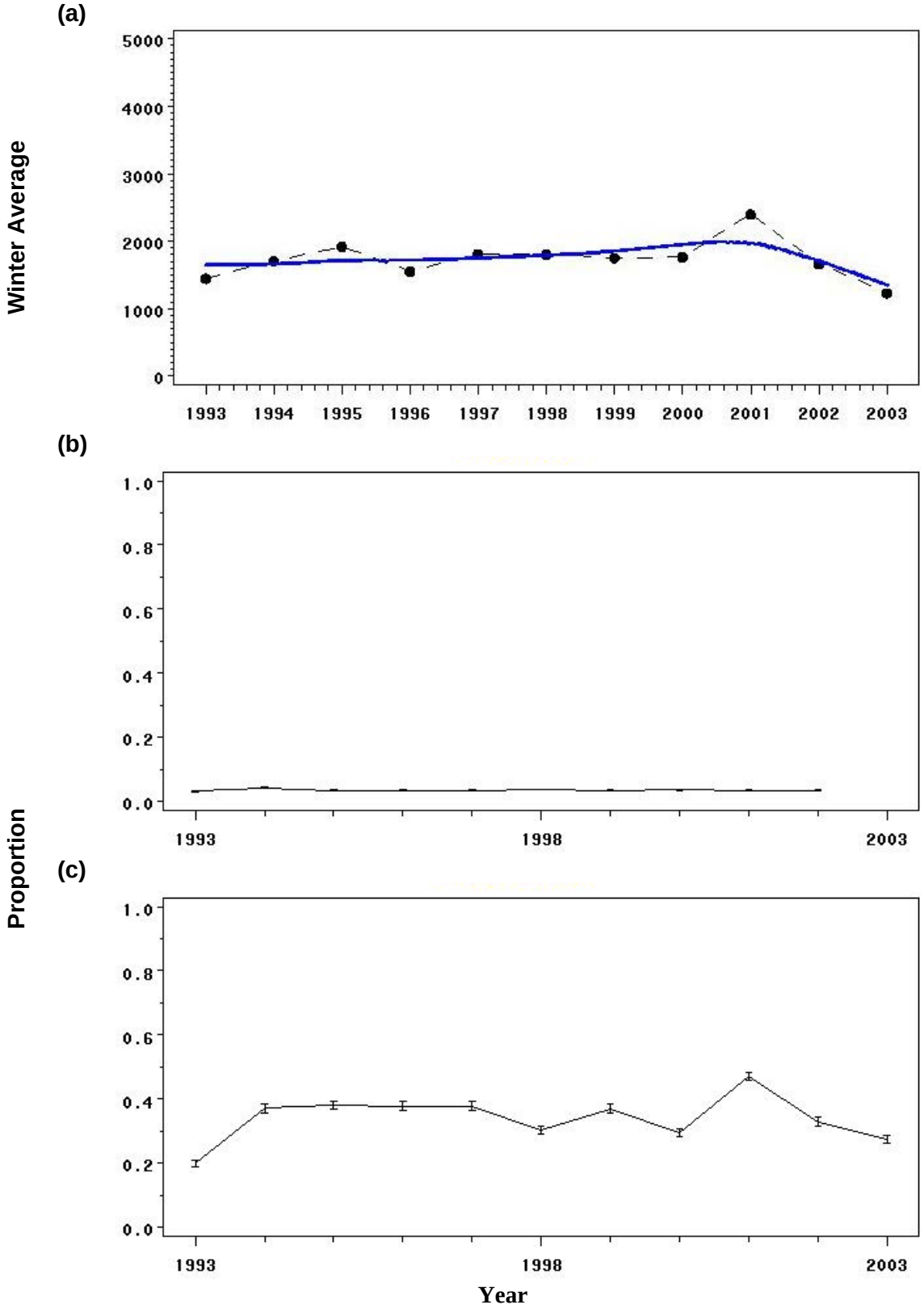


Figure 3.1.7 Teal (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

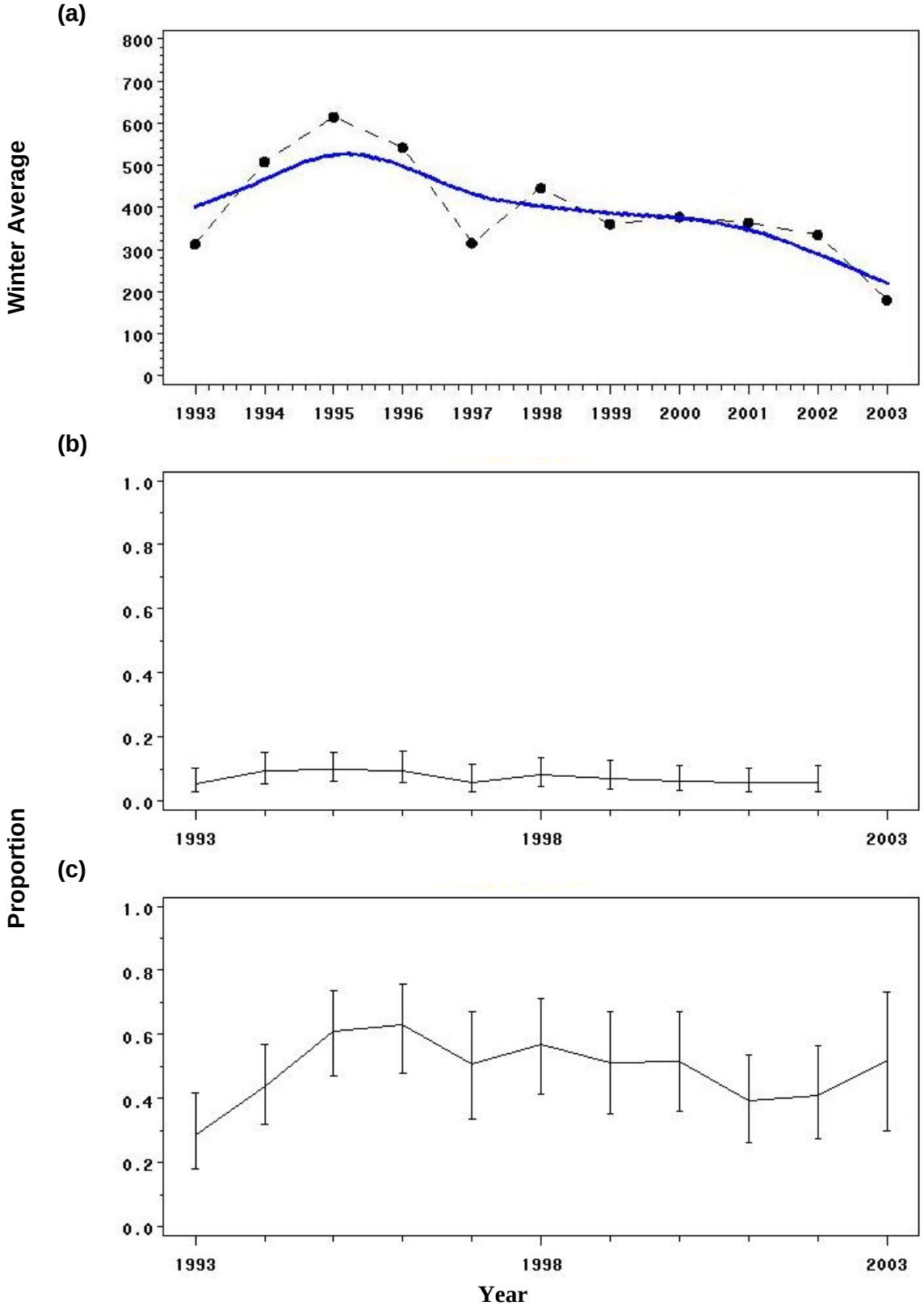


Figure 3.1.8 Pintail (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

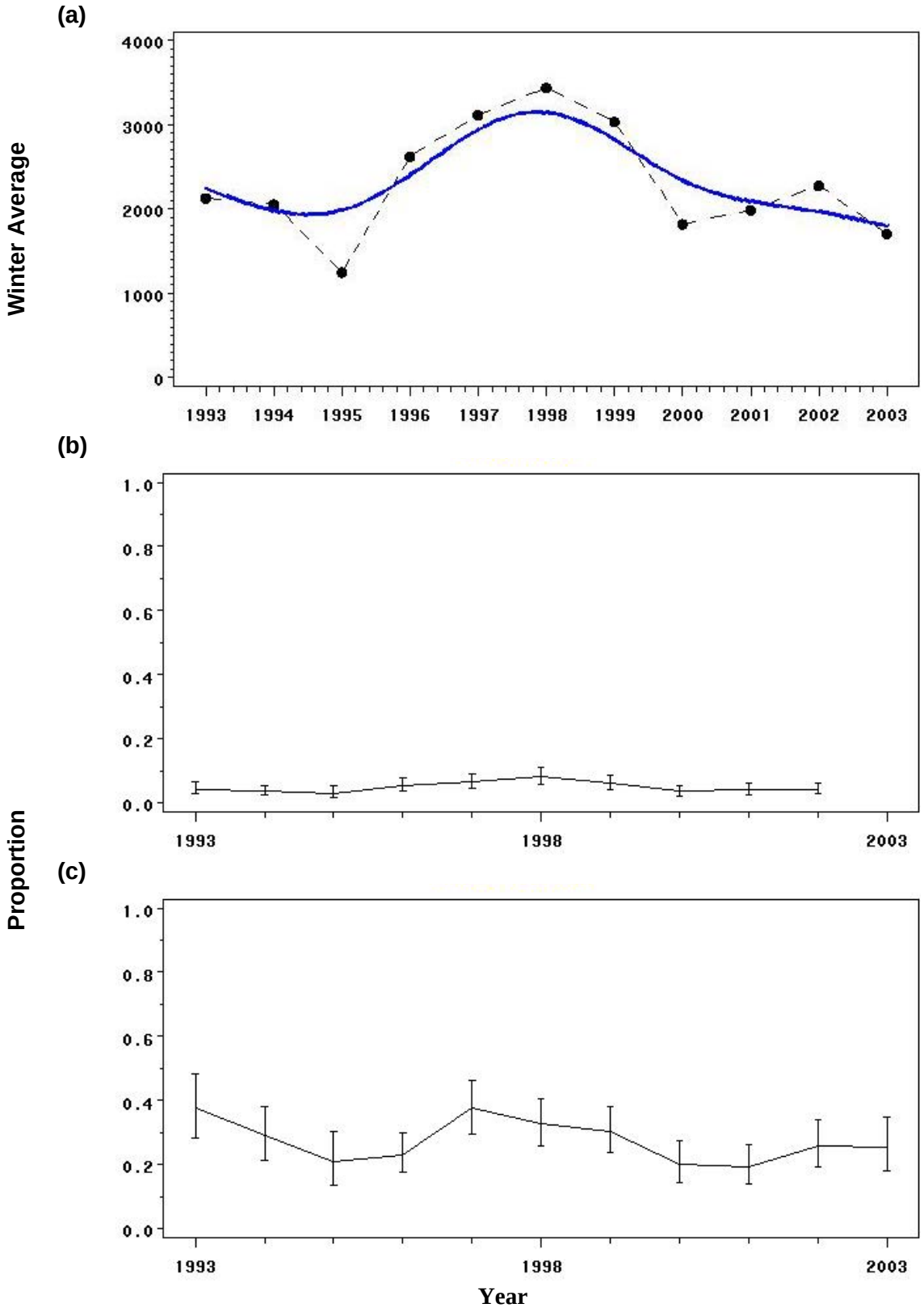


Figure 3.1.9 Oystercatcher (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

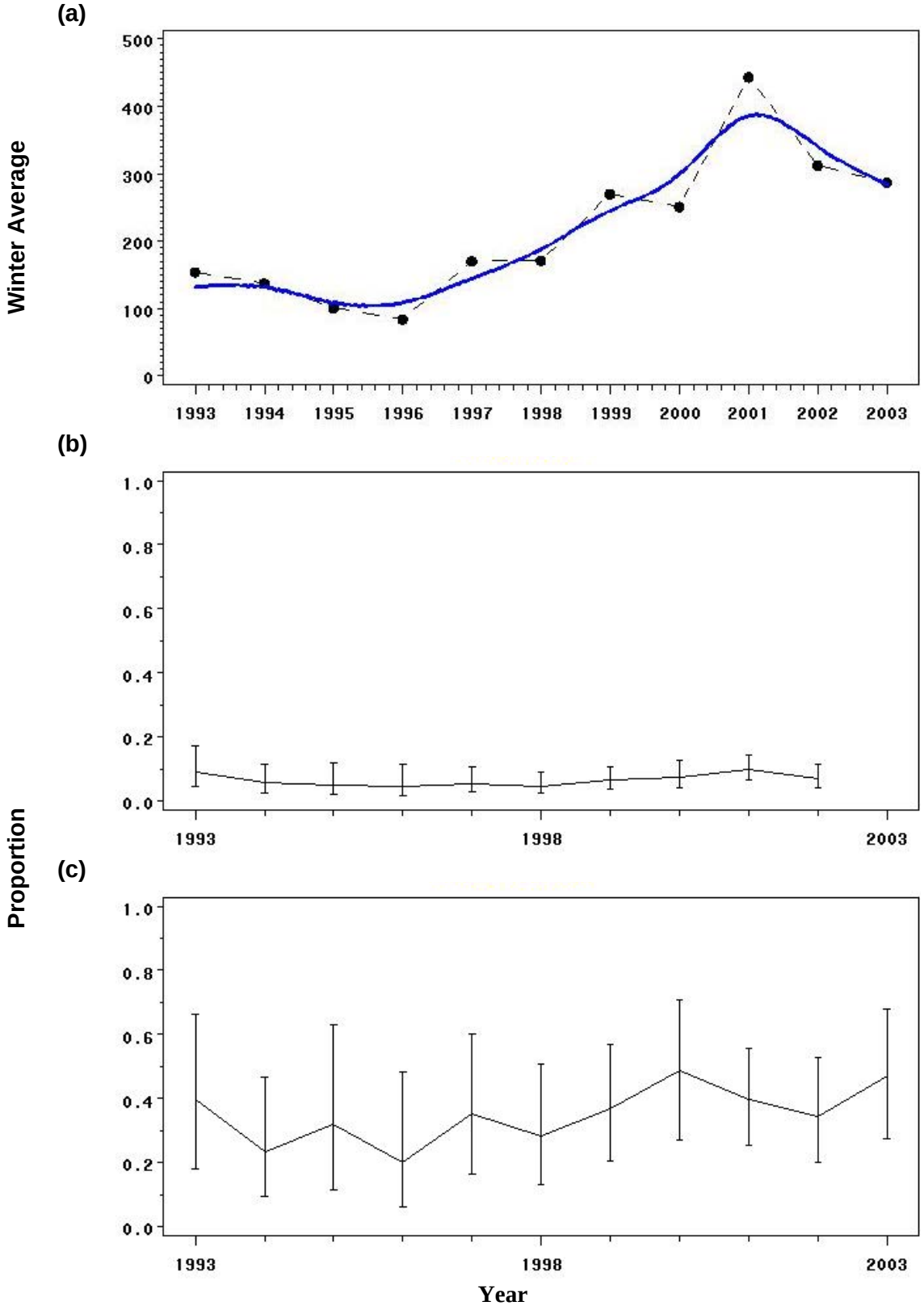


Figure 3.1.10 Avocet (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

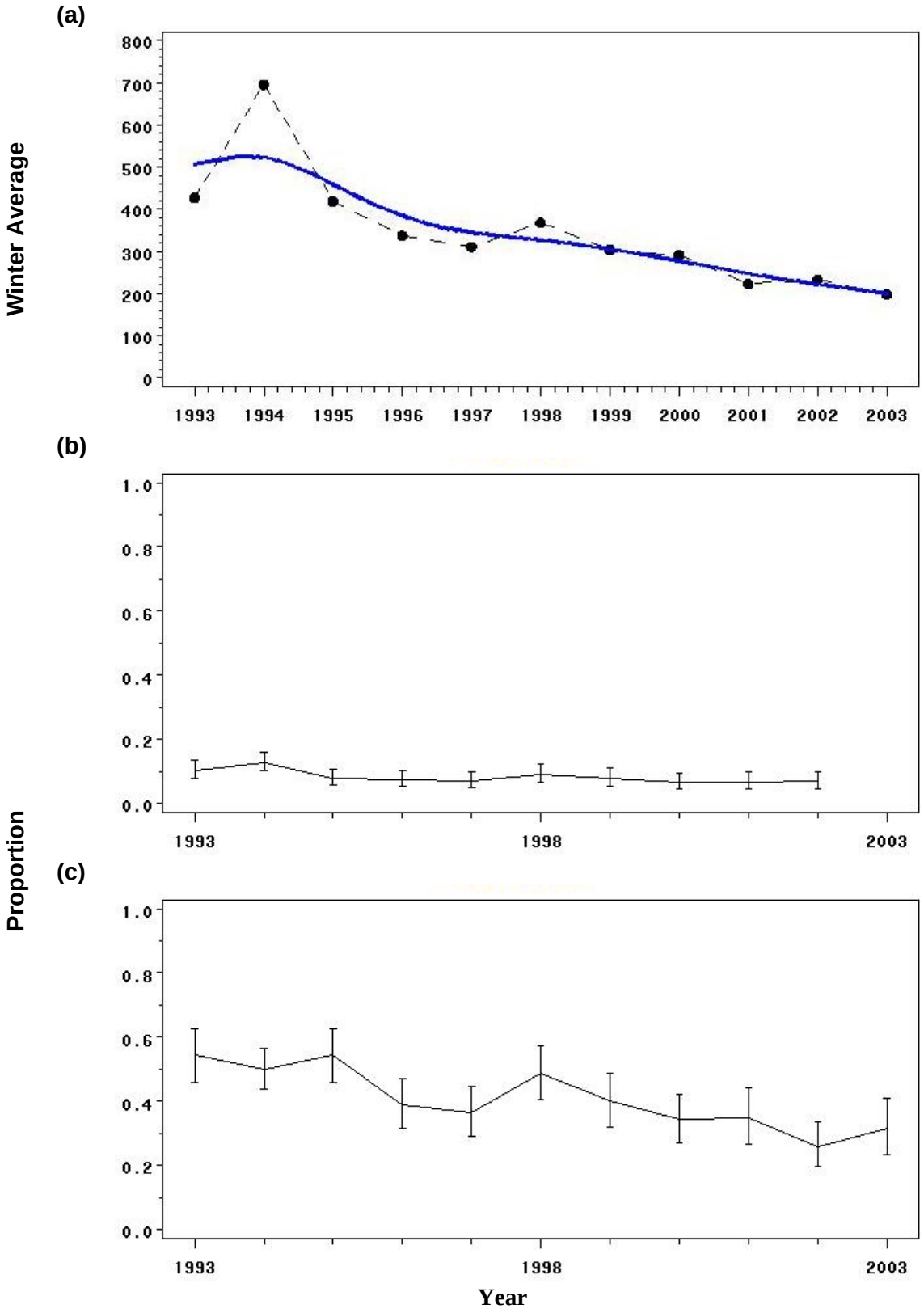


Figure 3.1.11 Ringed Plover (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

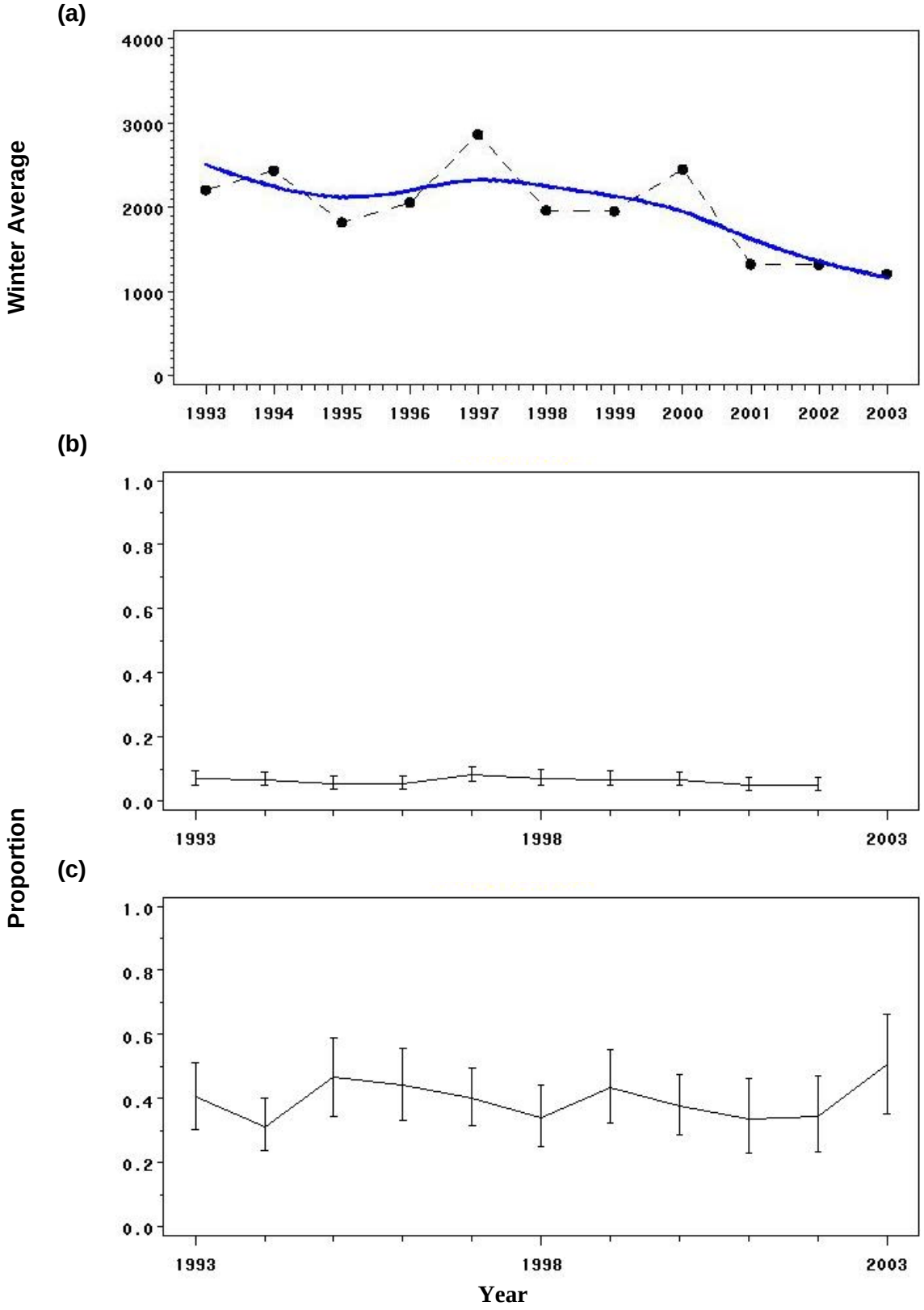


Figure 3.1.12 Grey Plover (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

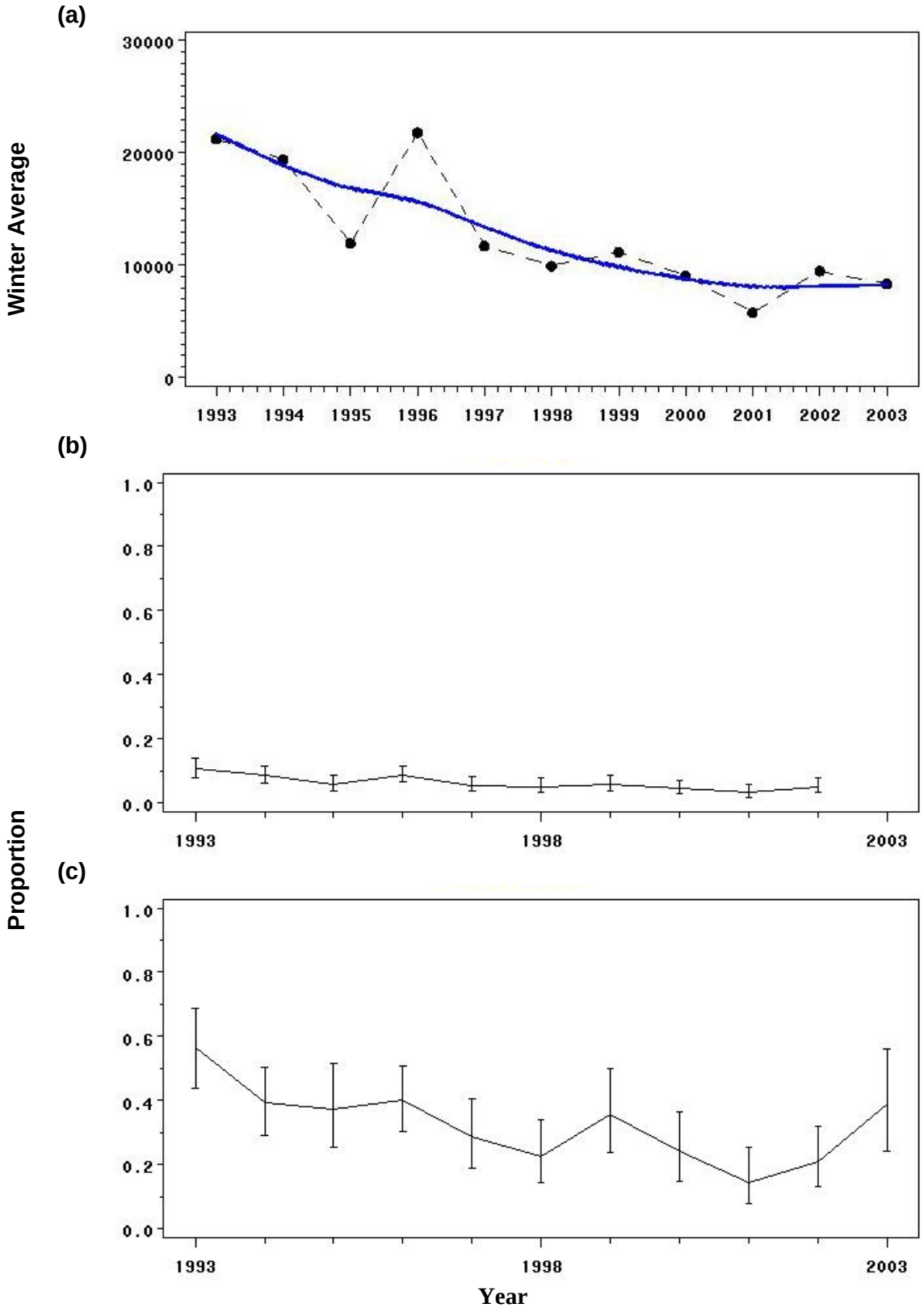


Figure 3.1.13 Dunlin (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

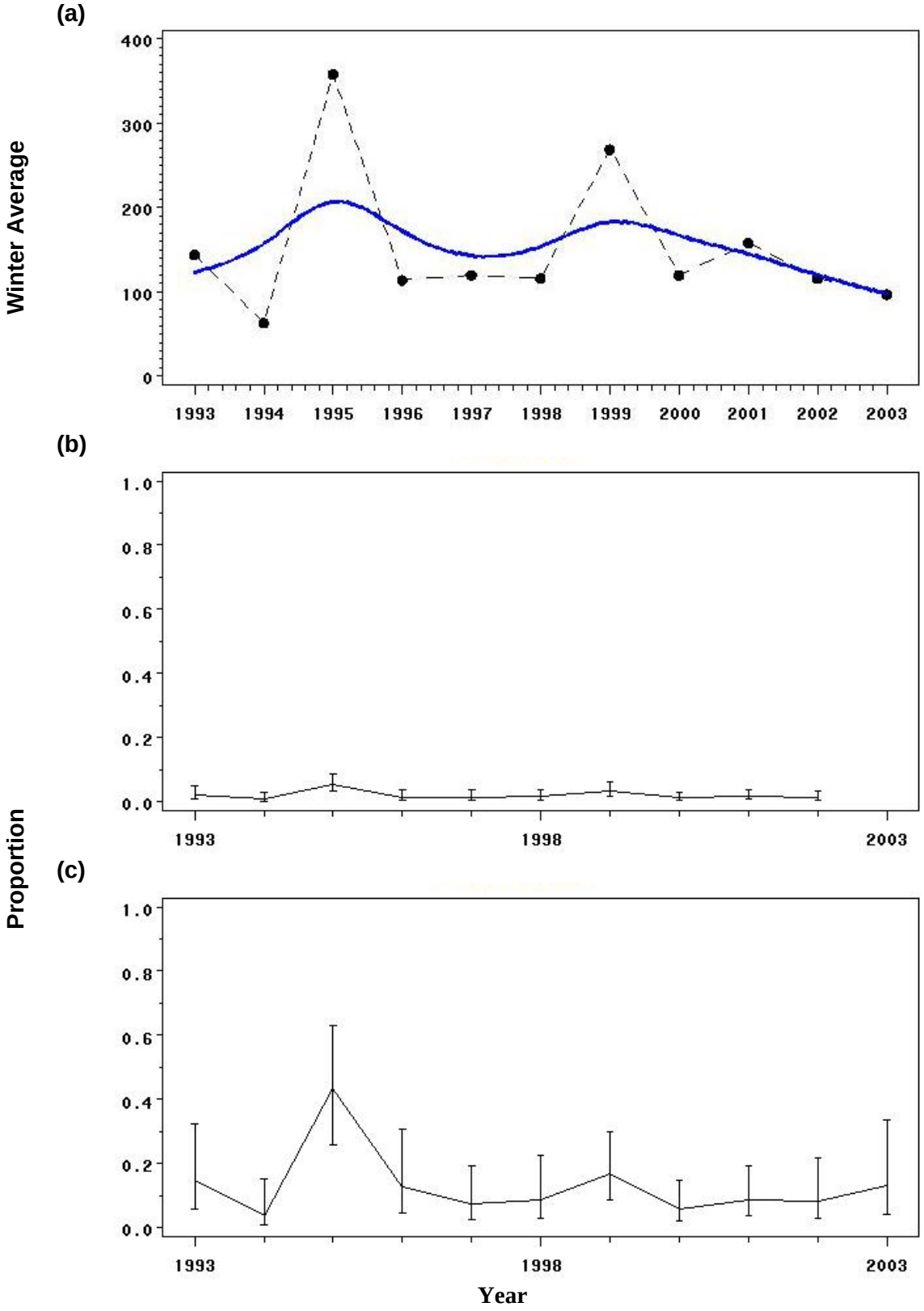


Figure 3.1.14 Black-tailed Godwit (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

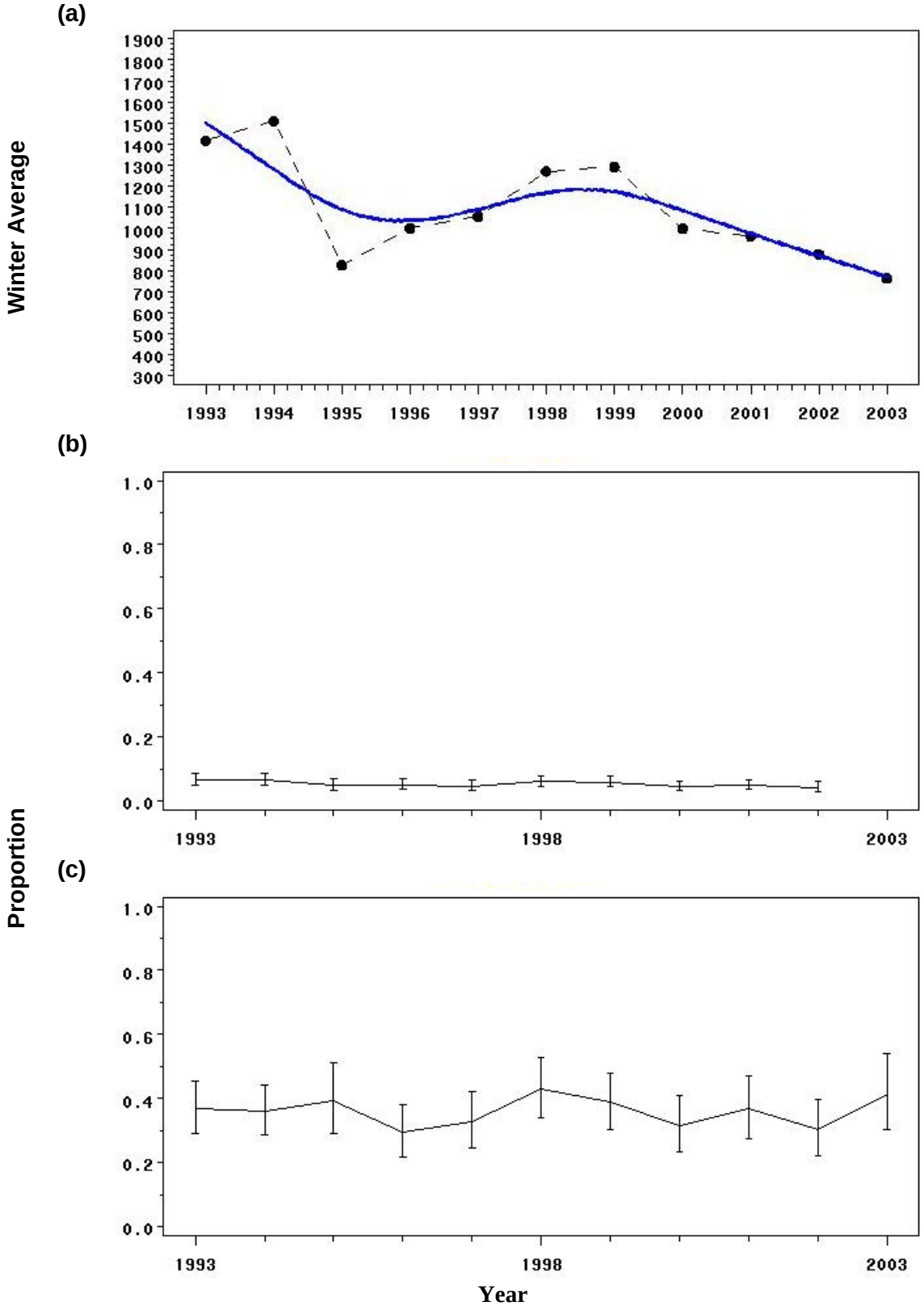


Figure 3.1.15 Curlew (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

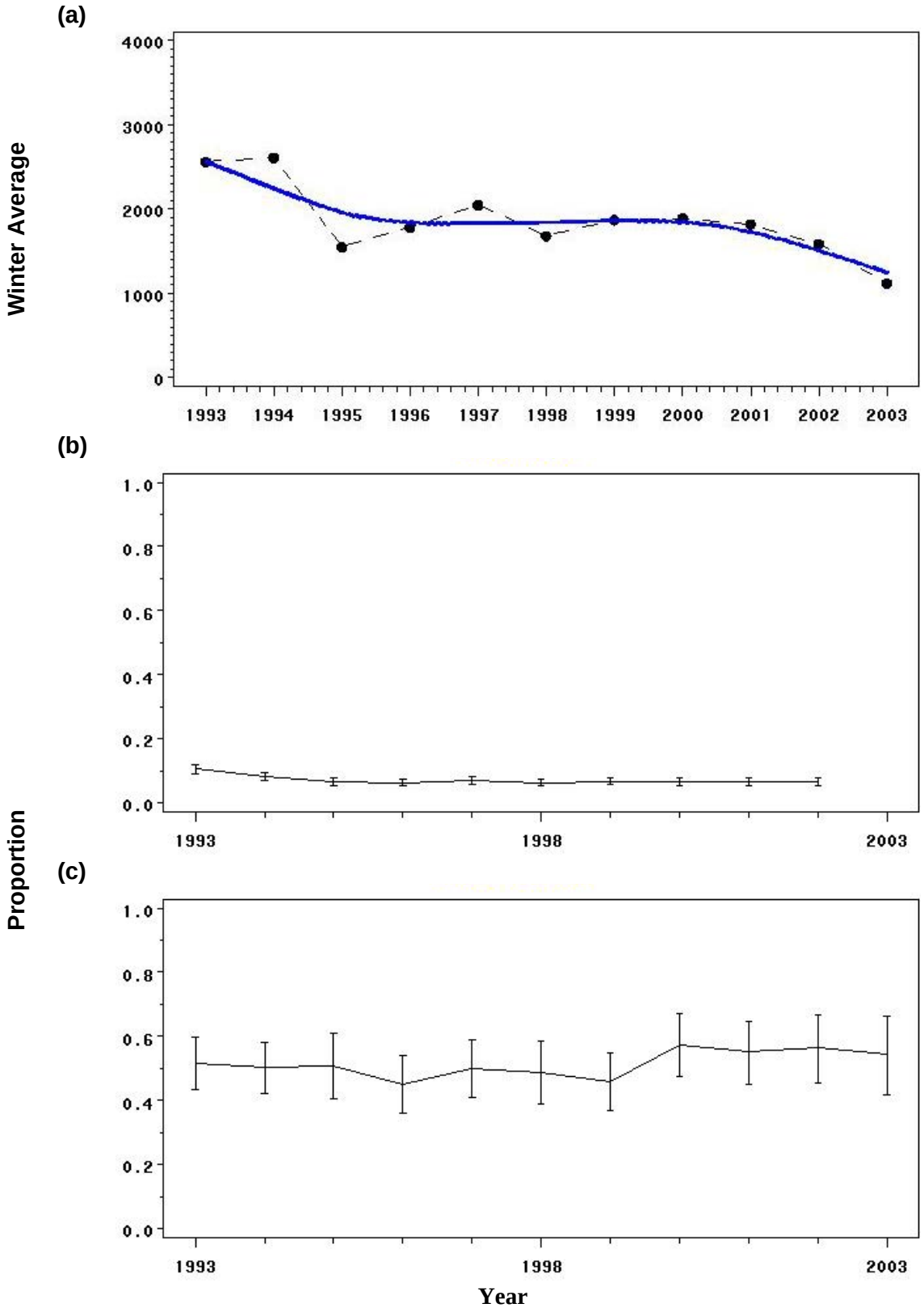


Figure 3.1.16 Redshank (a) Medway Estuary & Marshes SPA average winter count and smoothed GAM trend (b) Proportion of birds on the Medway Estuary & Marshes SPA compared to regional totals (c) Proportion of birds on the Medway Estuary & Marshes SPA compared to local area. 1993 = 1993/94, etc.

3.2 Sector Plot Analysis

Waterbird trends were calculated for all 16 species for each of the 13 WeBS Core Count sectors of the Medway, the six sectors of the Swale and 16 sectors of the Thames. Discussion of these trends is limited to those for which Alerts were triggered for the most recent 5- or 10-year period.

When referring to WeBS sectors, the numbers given are National Wildfowl Count (NWC) codes, the standard reference system for identifying WeBS sectors. The name of the sector, according to the WeBS database, is presented on the first appearance of the sector code; subsequently only the code is used. Maps with sector plots are provided in Appendices 1.1.1 – 1.1.3. A table of all sector codes and names can also be referred to (Appendix 1.1.4).

3.2.1 Great Crested Grebe

The largest concentrations of Great Crested Grebe were found on two sectors, Motney and Otterham Creek (NWC #22974) and Ham Green (#22978), although three further sectors (#22963, Barksore & Funton; #22967, Hoo, Nor, Bishop and Copperhouse Marshes; and #22972, Kingsnorth) supported average counts of 10 birds or less. Declines are evident on both of the former sectors, and as they are adjacent a similar factor could be involved.

However, on neither the Swale or Thames Estuaries are concurrent increases in Great Crested Grebes evident. Indeed, a comparable decline (although with fluctuation) was apparent on the nearby Cliffe Pits and Pools (#22231). There thus seems to be no evidence for large-scale and sustained movement of Great Crested Grebe between these SPAs.

3.2.2 Dark-bellied Brent Goose

In 1993/94, the greatest winter averages of this species were counted on two main sectors, #22967 and #22964 (Burntwick, Greenborough and Slayhills). The subsequent winters have seen consistent declines, punctuated with brief peaks that never exceeded the 1993/94 figure. Other shallower declines are evident on sectors also containing grazing marshes.

Comparatively few Dark-bellied Brent Geese were counted on the Thames Estuary, peak winter average counts never exceeding 900 (compared to ca. 3,000 on the Medway in 1993/94). No large increases were recorded on the Thames WeBS sectors. Patterns on the Swale Estuary are more interesting, as there have been fluctuations between winters. Generally, all sectors supporting substantial numbers of this species have shown declines in the last two years of analysis, and so overall trends are stable or changing only slightly. Certainly there are no sector trends that suggest influxes of birds not previously using the sites.

3.2.3 Shelduck

A number of sectors on the Medway have traditionally held sizable aggregations of Shelduck, with the greatest concentration found at #22967, an area also favoured by Dark-bellied Brent Geese. From 1993/94 to 1995/96, steep declines occurred in the winter average of this species, since when the trend has stabilised.

The vast majority of Shelduck on the Swale Estuary were counted on sector #22449, Elmley Marshes (an RSPB reserve since 1975). The trend for this species is adversely affected by an imputed value (based on the regional trend) in 2003/04. Without this outlier, the trend would be largely stable, suggesting that Shelduck numbers are neither increasing or declining at this site. Thus there is no evidence of movements from the Medway to the Swale. The pattern across those sectors of the Thames supporting Shelduck are similar to those on the Medway; most sectors show declines or stability, with no apparent long-term increases.

3.2.4 Pintail

The decline of Pintail on the Medway over the 5- and 10-year periods up to 2003/04 resulted in Medium Alerts, though for this species these should be interpreted cautiously owing to 'natural' fluctuations in numbers (Austin *et al.* 2004). However, as both declines were of 45%, there is perhaps real cause for concern. Greatest changes were apparent on sector #22963. Although this trend contains a number of imputed values, even those recent complete counts indicate declines. It is possible that some Pintail may have moved to the adjacent sector #22961 (Chetney Marshes) during the late 1990s, as increases were recorded there. Imputed values suggest any increases have recently been counterbalanced by declines to a level comparable with that in 1993/94.

The majority of Pintail on the Swale occur on Elmley Marshes; numbers here have fluctuated over the past 10 years, with a period of decline from 1993/94 to 1996/97 and a period of increase from 1999/2000 to 2001/02. Following this latest peak, declines have again followed in 2002/03 and 2003/04. Therefore it does not seem that this species has relocated to the Swale. Similarly, the general pattern for the Thames has, like the Medway, been one of decline. No sector displays a trend indicating local movement to the Thames.

3.2.5 Oystercatcher

A Medium Alert was triggered over the 5-year period on the Medway, owing mostly to declines since 1998/99 on sectors #22964, #22967 and #22961. Over this period, steep declines were also evident on the Thames at sector #25411 (Canvey Point). This is in sharp contrast to the trend at the principal sector for Oystercatcher on the Swale, #22447 (Shellness and Harty Marshes). On this sector, trends have increased markedly since 1998/99. It therefore seems likely that some Oystercatcher may have moved within the local area over the past five years, leaving the Medway and Thames and switching to the Swale.

3.2.6 Ringed Plover

The most severe declines of Ringed Plover on the Medway occurred on sector #22967, with numbers crashing from a peak in 1994/95. Elsewhere, shallower declines are evident on the adjacent sector #22972, and small but stable counts persist on six other sectors.

Interestingly, sector #25411 of the Thames shows a possible influx of Ringed Plover at around the time the large declines were recorded on the Medway. Numbers rose from below 50 to above 250 in 1994/95 and were sustained at this level for three winters after Ringed Plover numbers on sector #22967 of the Medway fell. The population on #25411 has subsequently fluctuated. A large but short-lived peak recorded on sector #25902 (Tilbury to Mucking) in 1994/95 reflects the pattern seen on sector #22967 of the Medway. Average winter counts on sector #22449 of the Swale Estuary were greatest between 1995/96 and 1999/2000 following the decline of Ringed Plover on the Medway; subsequently there have been occasional peaks on sector #22441. Therefore it seems likely that there was local dispersal away from the Medway after 1994/95.

3.2.7 Grey Plover

Three sectors of the Medway Estuary support the majority of the Grey Plover found on the SPA, each holding several hundred birds. These sectors are #22967, #22964, and #22973 (Stoke Saltings and Ooze). All three have undergone gradual but substantial declines over the period of analysis, with some fluctuation.

The winter of 1994/95 saw peaks in Grey Plover numbers on two sectors of the Thames (#25412, Leigh Marsh and Two Tree Island, and #25411). This pattern was repeated on one sector of the Medway (#22964) and so could reflect wider increasing trends rather than local movements. Peaks in the winter of 1997/98 are also consistent between sector #22973 of the Medway and sectors of #22449

and #22447 of the Swale (the latter sector shows a large influx of Grey Plovers, trebling the average count for the previous winter). One possible indication of localised movements is that at Shellness and Harty Marshes the species had undergone a sustained increase from 1993/94 to 1996/97, during which time there was a decline on sector #22967 on the Medway; these changes involve comparable numbers. It should be noted, however, that as the proportion of this species held by the Medway has remained fairly stable in relation to the local area (Figure 3.1.12c), any localised movements are likely to be of small significance in the context of the general decline across all three local estuaries.

3.2.8 Dunlin

Over the past 10 years, Dunlin numbers have plummeted on the Medway, leading to the issue of a High Alert. This trend is largely governed by the drastic declines on sector #22967. Numbers have dropped from well above 10,000 in 1993/94 to below 2,000 in 2003/04. Shallower declines, from smaller peaks, occurred on sectors #22973 and #22964.

The trends for the Thames Estuary do not provide compelling evidence of movement of Dunlin away from the Medway. Most sector trends are stable, with occasional punctuated increases. Sector #25411 appears to have supported increases over the 10-year period, but the 1993/94 figure is an imputed value based on the regional trend. Therefore the actual trend may have remained stable as in the following years. Alternatively, a real increase could have reflected some re-dispersal from the Medway, though would not explain the full extent of the Medway declines.

Smaller numbers of the species were found on the Swale Estuary. Patterns on these sectors were mainly stable over the 10-year period. Peak counts in the winters of 1996/97 and 1997/98 were evident on all sectors, however, which may account for the decrease in local importance for Dunlin of the Medway during the mid-1990s. These winters include the lowest counts on the Medway sector #22967, but the patterns do not fully account for the pre-1996/97 declines. However, the possibility remains that some Dunlin moved from the Medway to Shellness and Harty Marshes. The recent increase in proportion of the local population supported by the Medway suggests that Dunlin on the Swale and Thames estuaries may now be declining more rapidly than on the Medway, or that further localised movements favour the Medway as a roosting location.

3.2.9 Black-tailed Godwit

No particular sector of the Medway shows drastic declines, although the trend on sector #22964 is perhaps more obvious than the shallow declines on sectors #22974 and #22960 (Deadman's Island). The Thames supports some Black-tailed Godwits, but no sector shows substantial increases over the past five years. The Swale also holds hundreds of roosting Black-tailed Godwits, but the trends on the two major sectors (#22449 and #22452, Murston to Conyer) are notable for their recent declines. It would therefore appear that this species is in general decline in the local area, and is not subject to local area movements.

3.2.10 Curlew

In common with many of the waders, Curlew declines have been greatest at Hoo, Nor, Bishop and Copperhouse Marshes (#22967). Further, smaller declines were recorded on sector #22964. The combined effect of these changes led to a Medium Alert for the 10-year period, and a 49% decline is of serious concern.

Declines on the Swale resemble those on the Medway, generally occurring between 1993/94 and 1995/96, suggesting that Curlew were not switching between the sites, though numbers rose temporarily on #22449 in the late 1990s. However, five of the Thames Estuary sectors (#25414 (Vange and Holehaven Creek), #22484 (Cliffe and Cooling Marshes), #25412, #22481 (Yantlet and Allhallows) and #22086, North Grain) showed increases in the mid-1990s, suggesting the possibility that Curlew moved away from the Medway and Swale to the Thames. However, these peaks were

unsustainable on the whole, with trends fluctuating widely in other years. However, two of the sectors counted on the Thames (#25412 and #25414) have shown moderate increases over the 10-year period, implying that these areas may now be preferred by Curlew. Figure 3.1.15c suggests that the local proportion of Curlew held by the Medway has remained fairly stable, and so if internal local movements did occur between the Medway and the Swale and Thames, they are likely to have been of small significance in the context of the general decline across all three local estuaries.

3.2.11 Redshank

Continuing the pattern for many other species, Redshank numbers on the Medway underwent a severe decline between 1993/94 and 1996/97. The greatest declines were on sector #22967 where numbers fell from the peak of over 1,400 to just above 200 Redshank. Few changes were observed to the small numbers found on other sectors within the Medway Estuary.

The Swale Estuary showed increases in Redshank on one sector (#22447), but this was counterbalanced by declines on other sectors and perhaps represents only movements within the SPA. Trends on the Thames Estuary reveal some increases on sectors in 1994/95 and 1995/96, but these increases are transitory only, with overall trends stable or gradually declining. It is feasible that some movements of Redshank took place between the Medway and Thames in the early 1990s, but smoothed GAM trends also suggest that these increases could have represented fluctuations expected within a longer-term stable trend.

3.2.12 Other species

Of note are trends in Teal and Wigeon, both of which declined on sector #22967, the latter also on sector #22964. Teal showed an increase on sector #22091 (Stoke Fleet and Marshes) of the Thames, but the small numbers involved and geographical proximity between sectors perhaps render this finding unsurprising. Wigeon numbers have recently increased markedly on sector #22484 (Cliffe and Cooling Marshes) of the Thames Estuary and sector #22447 of the Swale Estuary, but the pattern of these increases is not concurrent with decreases on the Medway.

3.3 Core Counts vs Low Tide Counts

Low Tide Counts from the winters of 1996/97 and 2004/05 were compared to investigate whether declines in numbers of roosting birds also applied to birds using the site for feeding at low water. Appendix 1.2.1 shows a map of low tide count sectors within the estuary. A total of 33 sectors were counted on the Medway in the first count winter, with 15 surveyed in the second count winter (Appendix 1.2.2).

Tables 3.3.1 and 3.3.2 show the mean counts and mean densities of the nine species identified to be in serious decline according to Core Count data. Note that, as fewer sectors were counted in the later of the winters, the counts are not directly comparable and caution should be taken in interpreting changes in mean density, as the sectors counted are not all the same.

Species	Area (ha)	Mean count	Mean density
Great Crested Grebe	3,819	59	0.02
Dark-bellied Brent Goose	3,819	1,226	0.32
Shelduck	3,819	3,627	0.95
Pintail	3,819	675	0.18
Ringed Plover	3,819	430	0.11
Grey Plover	3,819	1,583	0.41
Dunlin	3,819	21,151	5.54
Curlew	3,819	650	0.17
Redshank	3,819	2,149	0.56

Table 3.3.1 Mean counts and densities of declining species on the Medway Estuary, from WeBS Low Tide Counts 1996/97.

Species	Area (ha)	Mean count	Mean density
Great Crested Grebe	2,552	25	0.01
Dark-bellied Brent Goose	2,552	1,059	0.41
Shelduck	2,552	1,555	0.61
Pintail	2,552	456	0.18
Ringed Plover	2,552	157	0.06
Grey Plover	2,552	302	0.12
Dunlin	2,552	7,374	2.89
Curlew	2,552	320	0.13
Redshank	2,552	917	0.36

Table 3.3.2 Mean counts and densities of declining species on the Medway Estuary, from WeBS Low Tide Counts 2004/05.

Further analyses were undertaken to generate index values based on Low Tide Counts and to assess the statistical significance of changes between the two count years. Note that these indices reflect the changes in numbers on just those sectors counted in both years and thus may not be completely representative of changes over the whole Medway. Due to relatively small sample sizes, significant changes were apparent for only three species, though indices are plotted for all.

Table 3.3.3 illustrates that there were no significant increases for any species, though there were upward trends for Little Grebe, Avocet and Black-tailed Godwit. The first two species have shown consistent increases in Core Count numbers over the last 10 years and thus can be considered to be undergoing general expansion on the Medway (Figure 3.3.1, Figure 3.3.10). The declining Core Count trend of Black-tailed Godwit suggests that some of the birds that feed in the estuary may now roost elsewhere (Figure 3.3.14).

For three species: Dark-bellied Brent Goose, Teal and Curlew, there was no discernable trend in the Low Tide Count index (Table 3.3.3, Figures 3.3.4, 3.3.7 & 3.3.15). For Teal, this pattern resembles the Core Count trend and is likely to reflect stability in the local population. However, the other two

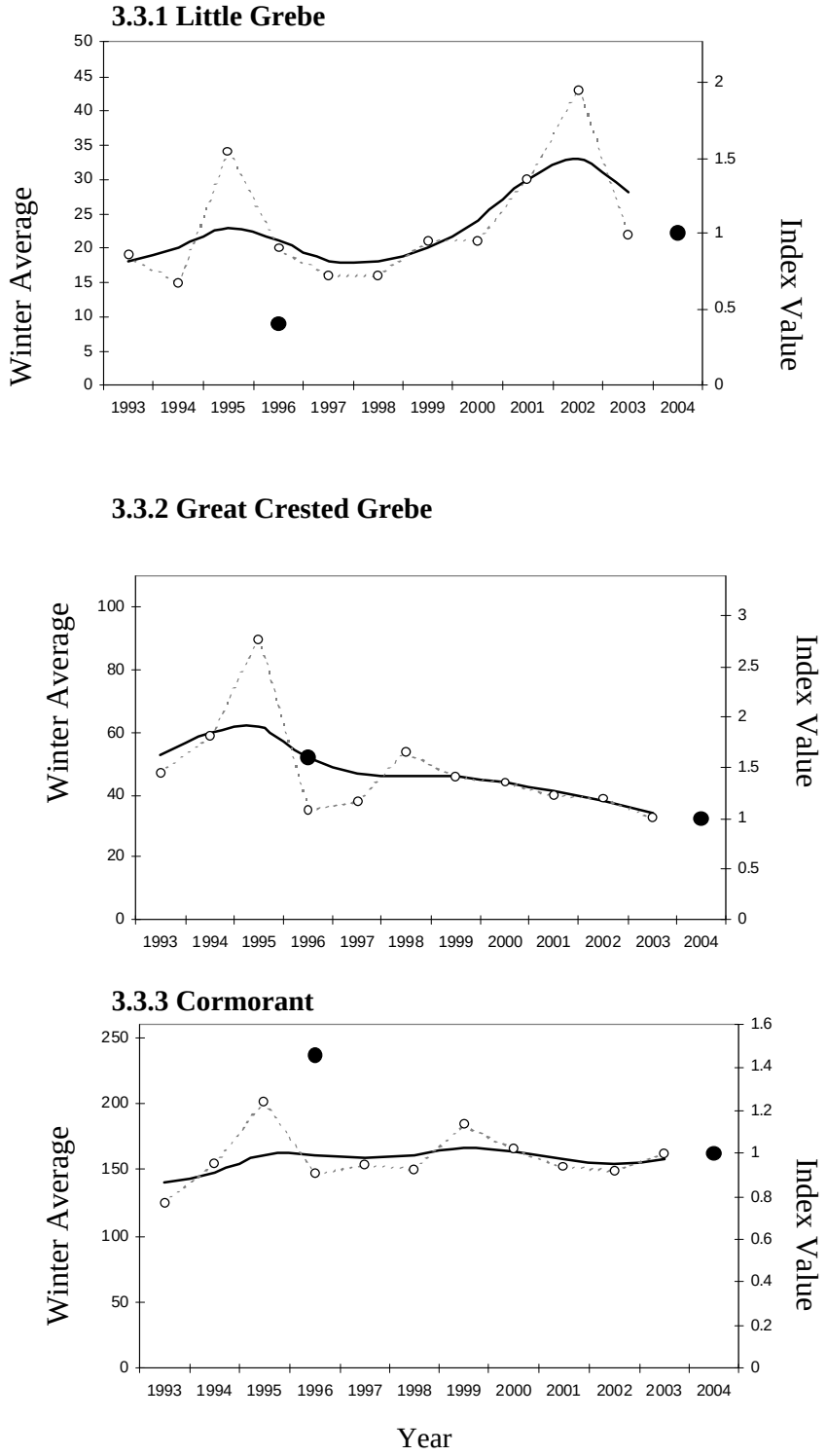
species were identified as being in decline on the Medway (section 3.1.8) and it is possible, therefore, that site level changes have impacted numbers of roosting, but not feeding birds.

Of the other species analysed, three showed significant declines in numbers recorded at low water: Shelduck, Oystercatcher and Grey Plover (Table 3.3.3, Figures 3.3.5, 3.3.9 & 3.3.12). Seven further species also showed insignificant downward trends: Great Crested Grebe, Cormorant, Wigeon, Pintail, Ringed Plover, Dunlin and Redshank (Table 3.3.3, Figures 3.3.2, 3.3.3, 3.3.6, 3.3.8, 3.3.11, 3.3.13 & 3.3.16). With the exception of Cormorant and Wigeon all had also shown declines in their Core Count numbers, implying that these species now use the Medway in a reduced capacity at both extremes of the tidal cycle.

Cormorant and Wigeon showed stable Core Count numbers (Figure 3.3.3, Figure 3.3.6) suggesting that some of the birds of these species that roost on the Medway feed elsewhere at low tide, as might be expected for species not reliant on intertidal or saltmarsh habitat.

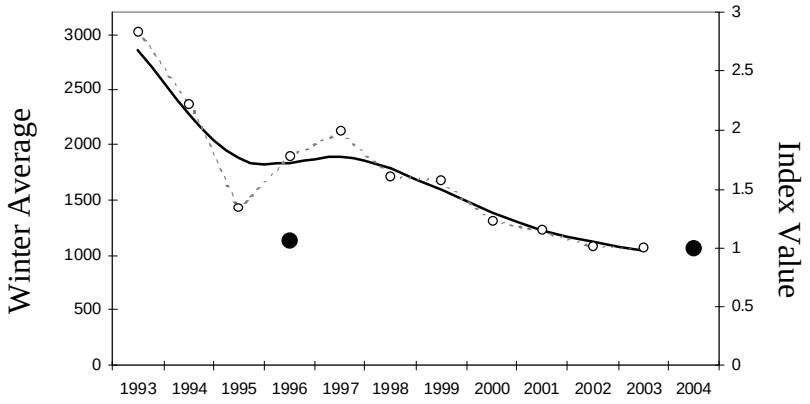
Species	*F*	*P*	Direction of change	Significance
LG	$F_{1,9} = 1.31$	0.2826	+	NS
GG	$F_{1,65} = 1.97$	0.1650	-	NS
CA	$F_{1,82} = 1.83$	0.1799	-	NS
DB	$F_{1,99} = 0.05$	0.8232	=	NS
SU	$F_{1,98} = 10.50$	0.0016	-	**
WN	$F_{1,76} = 2.13$	0.1489	-	NS
T.	$F_{1,68} = 0.00$	0.9564	=	NS
PT	$F_{1,44} = 2.27$	0.1391	-	NS
OC	$F_{1,96} = 5.47$	0.0214	-	*
AV	$F_{1,56} = 1.61$	0.2096	+	NS
RP	$F_{1,79} = 3.45$	0.0668	-	NS
GV	$F_{1,99} = 28.38$	<.0001	-	**
DN	$F_{1,100} = 3.25$	0.0745	-	NS
BW	$F_{1,76} = 2.44$	0.1228	+	NS
CU	$F_{1,99} = 0.18$	0.6747	=	NS
RK	$F_{1,100} = 1.01$	0.3163	-	NS

Table 3.3.3 F statistic, *P*-value and significance level of year effects from Generalised Linear Modelling. **P* <0.05; ***P* <0.01; NS = Not Significant at $\alpha = 0.05$.

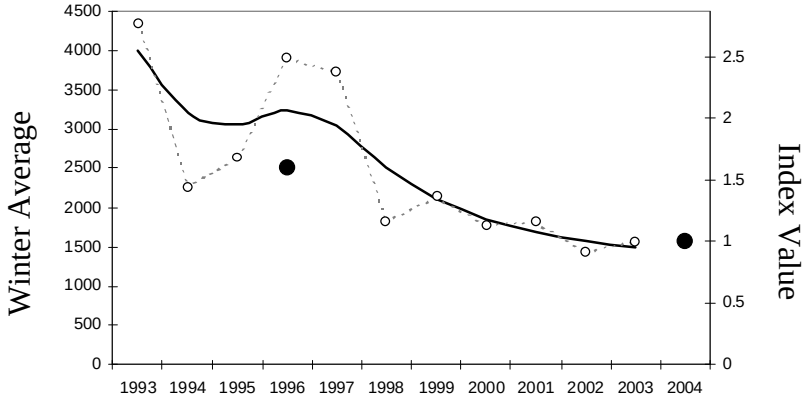


Figures 3.3.1 – 3.3.3 Ten-year smoothed Core Count trend (thick line) with winter averages (open circles, dotted line). Low Tide Count index values (filled circles) scaled to Core Count winter average for last winter available (2003/04).

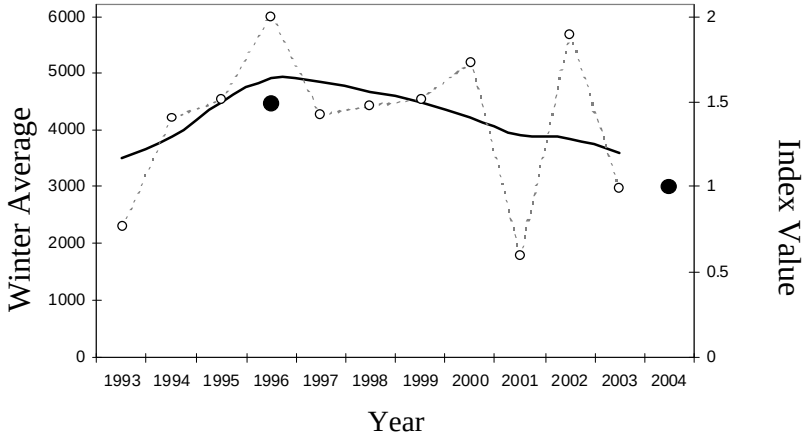
3.3.4 Dark-bellied Brent Goose



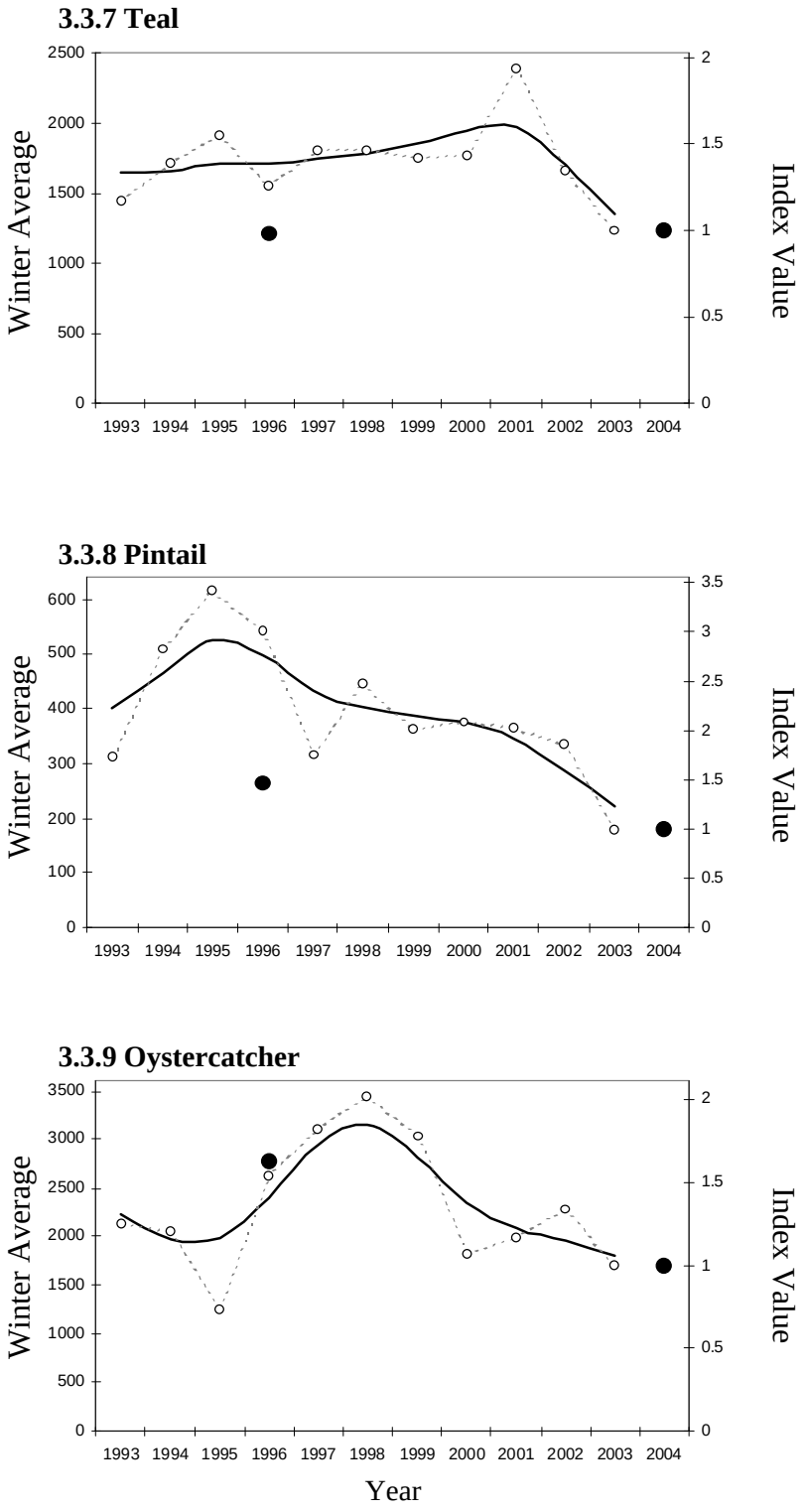
3.3.5 Shelduck



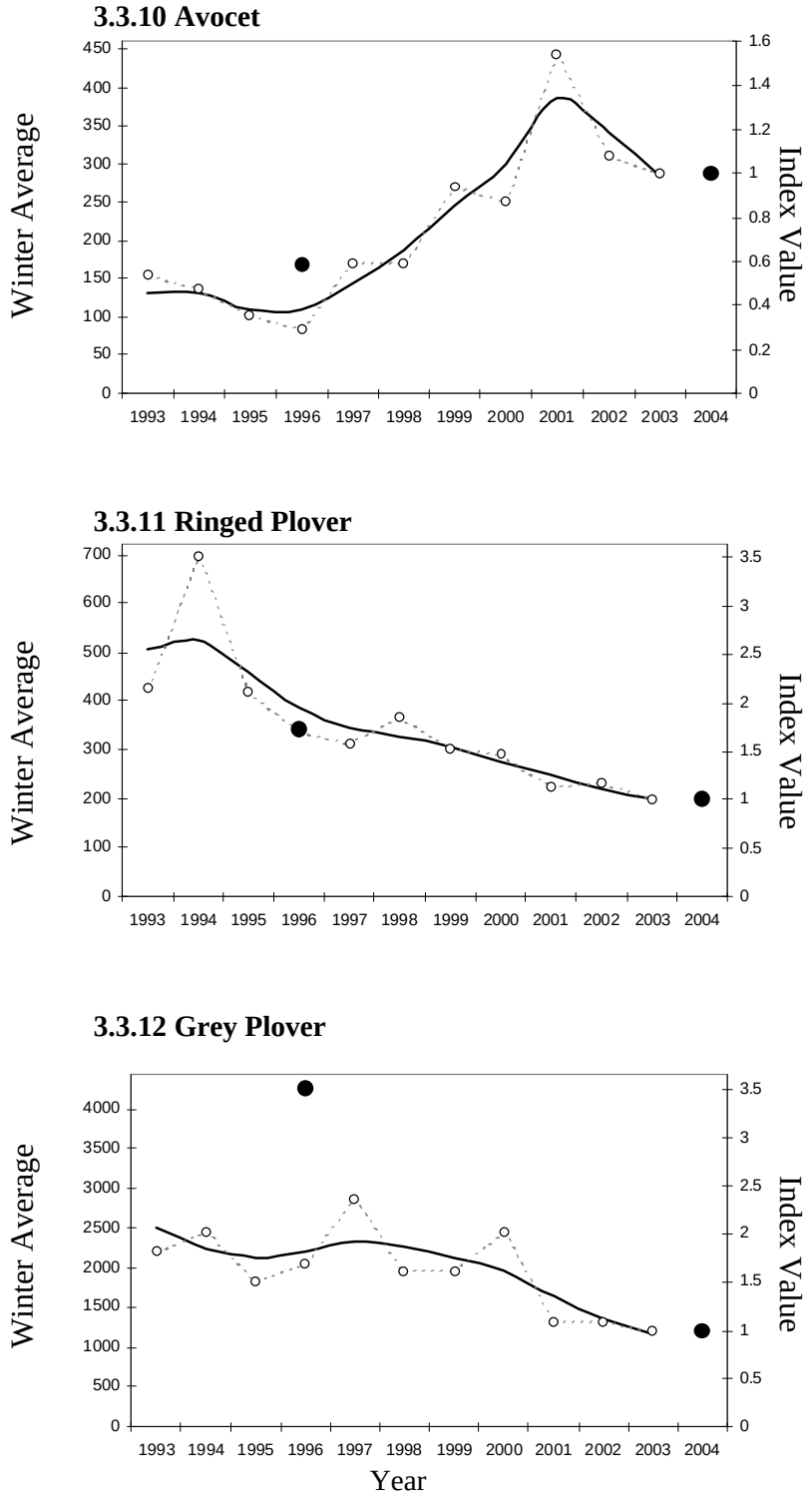
3.3.6 Wigeon



Figures 3.3.4 – 3.3.6 Ten-year smoothed Core Count trend (thick line) with winter averages (open circles, dotted line). Low Tide Count index values (filled circles) scaled in 2004/05 to Core Count winter average for last winter available (2003/04).

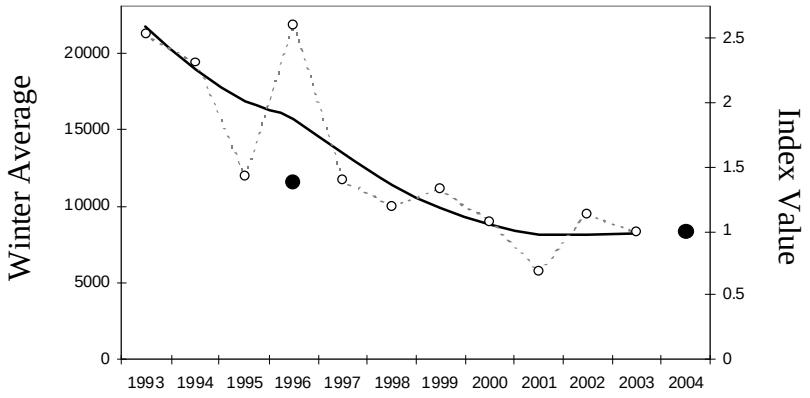


Figures 3.3.7 – 3.3.9 Ten-year smoothed Core Count trend (thick line) with winter averages (open circles, dotted line). Low Tide Count index values (filled circles) scaled in 2004/05 to Core Count winter average for last winter available (2003/04).

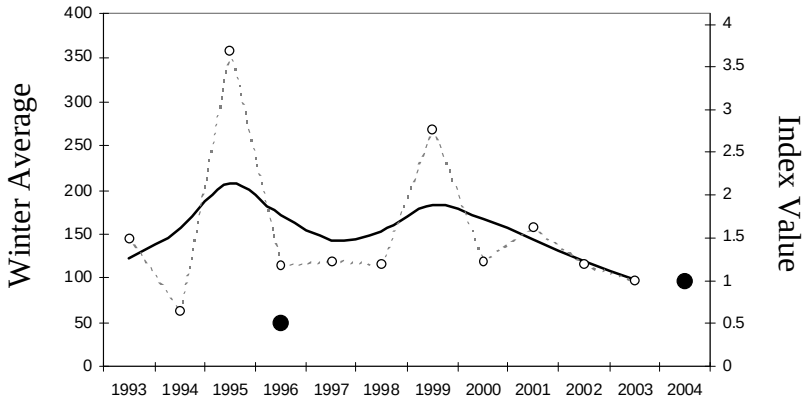


Figures 3.3.10 – 3.3.12 Ten-year smoothed Core Count trend (thick line) with winter averages (open circles, dotted line). Low Tide Count index values (filled circles) scaled in 2004/05 to Core Count winter average for last winter available (2003/04).

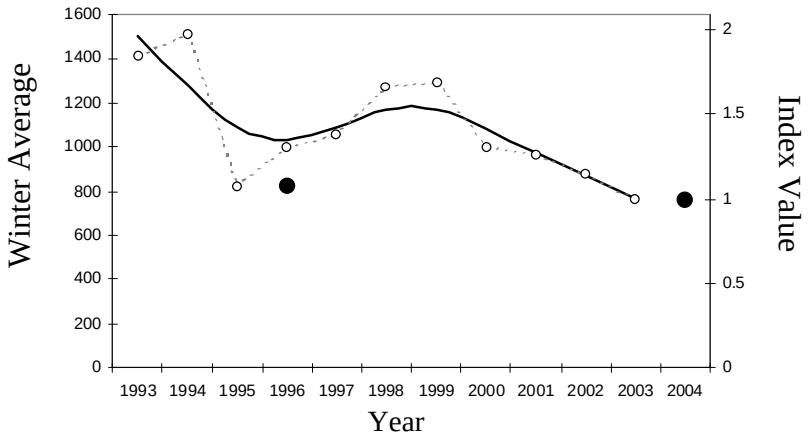
3.3.13 Dunlin



3.3.14 Black-tailed Godwit



3.3.15 Curlew



Figures 3.3.13 – 3.3.15 Ten-year smoothed Core Count trend (thick line) with winter averages (open circles, dotted line). Low Tide Count index values (filled circles) scaled in 2004/05 to Core Count winter average for last winter available (2003/04).

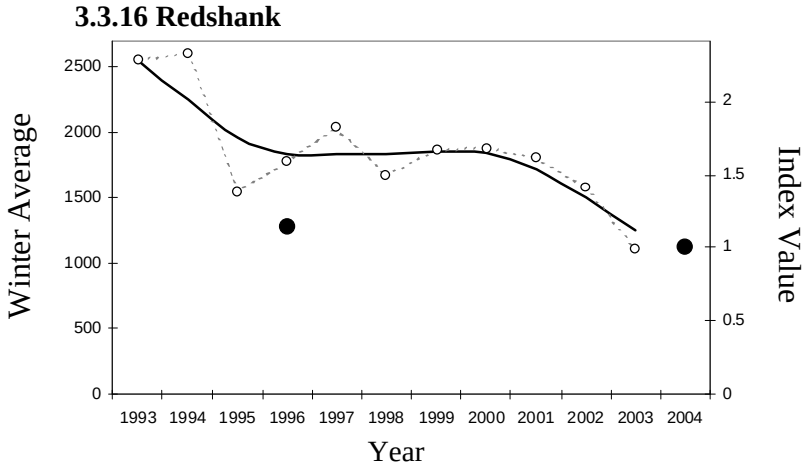


Figure 3.3.16 Ten-year smoothed Core Count trend (thick line) with winter averages (open circles, dotted line). Low Tide Count index values (filled circles) scaled in 2004/05 to Core Count winter average for last winter available (2003/04).

4. DISCUSSION

4.1 Waterbird declines on the Medway Estuary & Marshes SPA

Eleven species of waterbird were identified as declining seriously on the Medway Estuary over the period 1993/94 to 2003/04. Of these, six (including four species of wader) had declined by greater than 50% over the 10-year period, and were flagged by High Alerts. An additional three species declined by 25-49% and were flagged with Medium Alerts. Medium Alerts were also issued for 11 species over the period 1998/99 to 2003/04.

These declines should be viewed in the context of changes over the same time period on the neighbouring Swale and Thames Estuaries. Estimated proportions of the regional and local populations held by the Medway give an indication of whether site level changes reflect wider trends. Although confidence limits around such estimates may be large, and trends may be distorted by years in which disproportionate counts are made on one of the site complexes considered, this measure is effective at broadly elucidating such changes.

Of the nine species considered for sector plot analysis, two revealed strong evidence of declines not consistent with the local or regional trends, these being Ringed Plover and Dunlin. Although both species are in recent regional decline (Austin *et al*. 2004), the proportional estimates suggest that rates of change are more rapid on the Medway than the surrounding local or regional sites also holding the species.

The remaining seven species showed declines, which appeared to lie in step with changes at the local level (*i.e.* including the Swale and Thames Estuaries), and in most cases also the regional level (note, however, that at this enlarged scale small yet important changes may go undetected when compared with bird assemblages orders of magnitude larger). The fact that the local proportions of these seven species remained consistent compared to the combined Swale and Thames population implies that any declines were applicable at the level of this site complex. It is possible that local movements could still hold relevance, even where local declines are in place. Firstly, it is possible that either the Swale or Thames individually may show species trends not revealed in the combined analysis. For example, steep declines on the Swale could exceed increases on the Thames, with shallow declines on the Medway, thus maintaining the proportion of local birds held by the Medway at an apparently consistent level. Furthermore, it is possible that 'buffer effect' dynamics (Brown 1969) could be in operation, whereby a generally declining population fills the best quality habitats preferentially. Local movements away from the Medway could reflect relocation to preferred sites on the Swale or Thames, themselves vacated by declining numbers of birds. In such an instance site managers may still wish to consider why local estuaries should attract birds from the Medway.

Many declines outlined here show longer term patterns. Austin *et al*. (2004) analysed waterbird trends on the Medway Estuary up to the winter of 1999/2000, and many of the species identified as of concern for that period have not changed in status. Shelduck, Ringed Plover, Dunlin and Redshank are still considered as High Alert species, whilst two species, Dark-bellied Brent Goose and Grey Plover, have increased from Medium to High Alert status. These six species are of greatest concern and will be focused on in this discussion.

4.2 Potential Movements Between the Medway Estuary and Neighbouring Areas

Any potential movements of birds between the Medway Estuary and neighbouring sites should be judged in the context of the analysis. Comparison of bird trends allows some estimation of where movements are likely to have occurred, but without dedicated research using tracking methods, these must remain speculative. Also, when considering such potential movements in the context of proportional changes related to other sites, the size of confidence limits around estimates should be borne in mind.

The four species of wader for which High Alerts were triggered (Ringed Plover, Grey Plover, Dunlin and Redshank) all showed some possible evidence of movement within the local area, as did Oystercatcher and Curlew (Medium Alert status). Of these species, Ringed Plover and Dunlin exhibit perhaps the most convincing support for movements away from the Medway.

Ringed Plover declined most steeply on the Medway as a whole between 1993/94 and 1997/98. During this time, increasing trends were seen at Canvey Point on the Thames and shallower increases were recorded on the Swale, at Elmley Marshes and sector #22441, which includes South Swale NNR. It is possible that management of these sites benefited numbers of Ringed Plover, attracted from the Medway.

In the case of Dunlin, the steepest declines were again in the period from 1993/94 to 1997/98, especially on sector #22967 of the Medway. The apparent increase during this time on the Thames is perhaps misleading, as it is reliant on an imputed value for 1993/94. However, across the Swale, several slight increases were noted and one large increase was evident on sector #22447, *i.e.* Shellness and Harty Marshes. This and smaller increases on the western end of the Swale seem to have counterbalanced much of the decline on the Medway.

These patterns may help to explain some periods of decline at the Medway, but changes do not always closely match between sites and years, and do not apply to all species. Furthermore sector plot analyses do not reveal what initiated declines and induced any between-site movements. The declines on WeBS sector #22967 on the Medway are of particular concern; this formerly important high tide roost site now holds far fewer birds than in 1993/94.

4.3 Low Tide Count comparison

Of the 16 species analysed, 11 showed similar changes in trends generated from Core Counts and Low Tide Counts. Two of these species, Little Grebe and Avocet, increased according to both count methods, and are known to be undergoing expansion in numbers at wider regional and national scales (Austin *et al*. 2004), whilst Teal numbers appeared stable both at roost and at low tide, in the latter instance perhaps because this species is often recorded on aquatic areas of count sectors which are unlikely to have changed appreciably in terms of habitat quality.

The remaining eight species exhibiting similar Core Count and Low Tide Count trends were all in decline. It is possible that piscivores such as the Great Crested Grebe have moved away from the Medway to nearby inland waterbodies as the regional trend is increasing (Austin *et al*. 2004), though any changes are likely to be driven by water quality and available piscine prey. The seven other species shown to be declining at low tide, and in step with Core Counts, are all dependent on intertidal feeding habitat to some extent, including Shelduck, Pintail and five wader species (Oystercatcher, Ringed Plover, Grey Plover, Dunlin and Redshank). Whilst Shelduck and Pintail were not thought to have relocated to nearby estuaries, the latter five species all exhibited some evidence of local movement within the complex of the Medway, Swale and Thames Estuaries. If any of these birds now preferentially roost away from the Medway, either locally or otherwise, it would seem that their feeding sites have also changed. Energetically this is to be expected if they are able to feed profitably close to their new roosting locations (Rogers 2003). It is, however, unclear which factor drove any potential local re-dispersal. Degradation of feeding habitat or a reduction in available prey resources at the Medway, such as might result from the proliferation of algal mats (Cabral *et al.* 1999), could lead waterbirds to seek new foraging areas, thus driving the need to find new roosting sites close by. Alternatively, diminishing roosting habitat, such as might result from sub-tidal saltmarsh erosion, could lead birds to leave traditional roosts for new sites, which in turn are closer to other feeding zones.

Interestingly, Black-tailed Godwit showed a slight increase in feeding numbers against a shallow decline in its Core Count trend. National and regional Core Count trends show that the species is undergoing large increases (Austin *et al*. 2004), and so it seems likely that feeding numbers have

increased in response to general population increases. It is possible that the recent 5-year decline identified in Core Count trends (section 3.1.14) will transpire to be within the 'normal' range of fluctuation for the species, once further counts are collected. For this species and also Dark-bellied Brent Goose and Curlew, it is possible that some of the birds that feed in the estuary now roost elsewhere.

4.4 Possible Causes of Declines and Movements away from the Medway

Many of the declines at the SPA level are related to large sector level declines. Of the six species identified to be in serious decline, all were shown to have suffered substantial decreases in numbers on sector #22967, that comprising Bishop Islands, Copperhouse Bay, Fry Island, Hoo Marsh and Nor Marsh RSPB Reserve. The adjacent sector #22964 (compromising Burntwick Island, Greenborough Marshes and Slayhills Marshes) was also implicated in several species declines.

4.4.1 Habitat change / loss

Various developments and natural processes are likely to have affected bird numbers within the SPA , which may ultimately lead to movements away from the site, particularly if foraging areas are adversely involved as birds tend to roost close to their feeding sites to minimise energy expenditure (Rogers 2003). Saltmarsh erosion is a common phenomenon on estuaries in southeast England (Burd 1992, Centre for Coastal Management 2002, Blair-Myers 2003) including the Medway. Many of the marshes within the SPA have eroded due to wave action and rising sea levels. Accretion has compensated some erosion, but problems with measurement prevent the extent of this being known (Centre for Coastal Management 2002). Reduced saltmarsh leads to a reduction of roosting areas, and for species such as Dark-bellied Brent Goose, reduced feeding opportunities. Increases in *Spartina* in the saltmarsh at the Medway, identified by Blair-Myers (2003), will have reduced the extent of the open mudflats available to foraging waterbirds: Goss-Custard & Moser (1988), investigating changes in Dunlin numbers in Great Britain, found that the greatest declines had occurred where there had been the greatest increase in *Spartina* cover. Likewise, growth of *Enteromorpha* in the Medway Estuary may have impacted food supplies.

Mudflat areas have also been lost on the Medway, with Lappel Bank incorporated into Sheerness dock. Mitigation sites have been analysed (Field *et al*. 1999, Banks *et al*. 2003), but compensation habitat will be created not on the Medway, but the Crouch-Roach complex (http://www.defra.gov.uk/news/2004/040304a.htm). Finally, increases in urban and recreational developments could also have impacted on the habitat available to birds on the Medway Estuary.

4.4.2 Climate change

Recent research has suggested that climate change may induce eastward shifts in distribution of migratory waterbirds (Austin & Rehfisch 2005). Although this has been shown to occur at the national level, it is unclear whether this might also apply on a continental scale. It is possible that in such a scenario, Shelduck, moulting on continental wintering grounds such as the Wadden Sea could avoid migration by enduring milder winters close to the moult sites. Similarly, birds could reduce the cost of migration by wintering closer to their breeding grounds (Austin & Rehfisch 2005). Such processes would lead to a decreasing number of birds observed wintering at the traditional locations in the UK.

4.4.3 National species trends

It is feasible that SPA level declines could simply reflect the trends of the entire UK population. Poor breeding seasons, adverse winter conditions or habitat loss at stopover sites can contribute to depressed population sizes and thus lower counts at the wintering sites used in Britain. Both the national index (Pollitt *et al.* 2003) and the national smoothed trend (Austin *et al.* 2004) for Dark-bellied Brent Goose, Shelduck, Ringed Plover and Dunlin show decline over the period of analysis for

this report. However, caution should be exercised, as rates of decline may differ at different scales, and national trends can mask local-level impacts.

4.4.4 Disturbance / development

As the majority of declines appear to be occurring in the south and west sections of the Medway Estuary, one possible consideration is the burgeoning urban and recreational development in this area. Expansion of the Hoo and Gillingham marinas is likely to have increased the numbers of boats using the estuary, and boating activity is thought to have a disturbing effect on waterbirds, even within estuarine RSPB reserves (Hirons & Thomas 1993). Similarly, the larger the urban developments of Gillingham, Chatham and Rochester become, the more people are likely to utilise the estuary for recreational activities such as walking and angling.

4.5 Final Conclusions

- WeBS Core Count data analysed for the period 1993/94 to 2003/04 suggest that six species showed declines of greater than 50%, and thus are flagged by High Alerts.
- For four of these species – Ringed Plover, Grey Plover, Dunlin and Redshank – as well as Curlew and Oystercatcher, there was evidence that declines may have been explained by movements to adjacent estuaries.
- The strongest evidence was for movements of Ringed Plover away from the Medway to Canvey Point on the Thames and Elmley Marshes and the Faversham to Whitstable sectors of the Swale; and movements of Oystercatcher, Grey Plover and Dunlin away from the Medway to the Swale, particularly Shellness and Harty Marshes.
- Of the 11 species identified to be in decline by Core Count data, eight also showed declines in their Low Tide Count trends, indicating that the factors leading to declines have similarly affected both roosting and feeding usage of the site.
- Factors that could have initiated declines on the Medway are discussed.

Acknowledgments

We would like to thank Lionel Solly at English Nature for project guidance and support. Mark Collier assisted with WeBS data extraction, and Emma Davis and Heidi Mellan kindly formatted the report. We thank Andy Musgrove for comments.

Data were supplied by the Wetland Bird Survey (WeBS), a joint scheme of the British Trust for Ornithology, The Wildfowl & Wetlands Trust, Royal Society for the Protection of Birds and Joint Nature Conservation Committee (the last on behalf of the Countryside Council for Wales, Department of the Environment Northern Ireland, English Nature and Scottish Natural Heritage).

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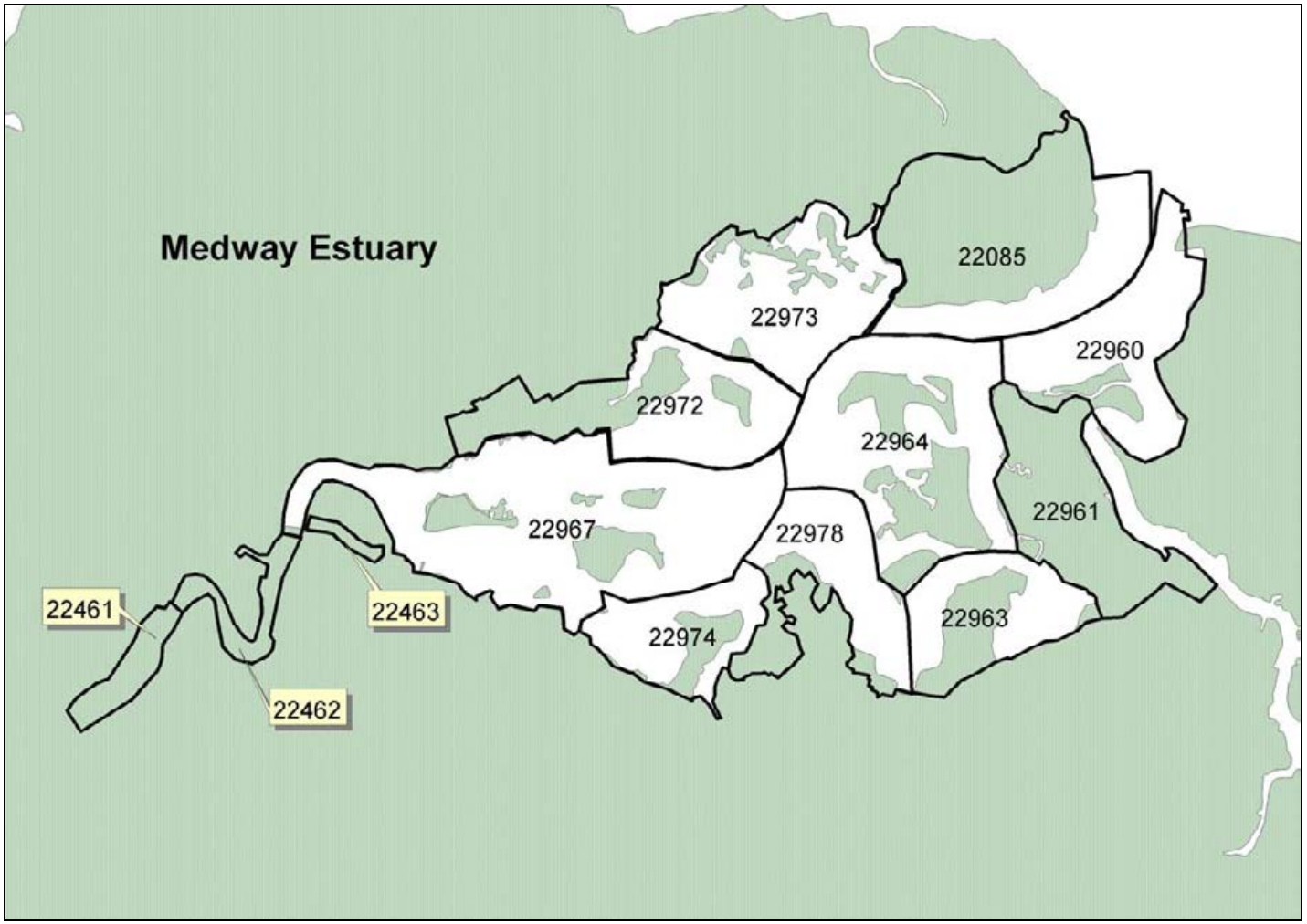
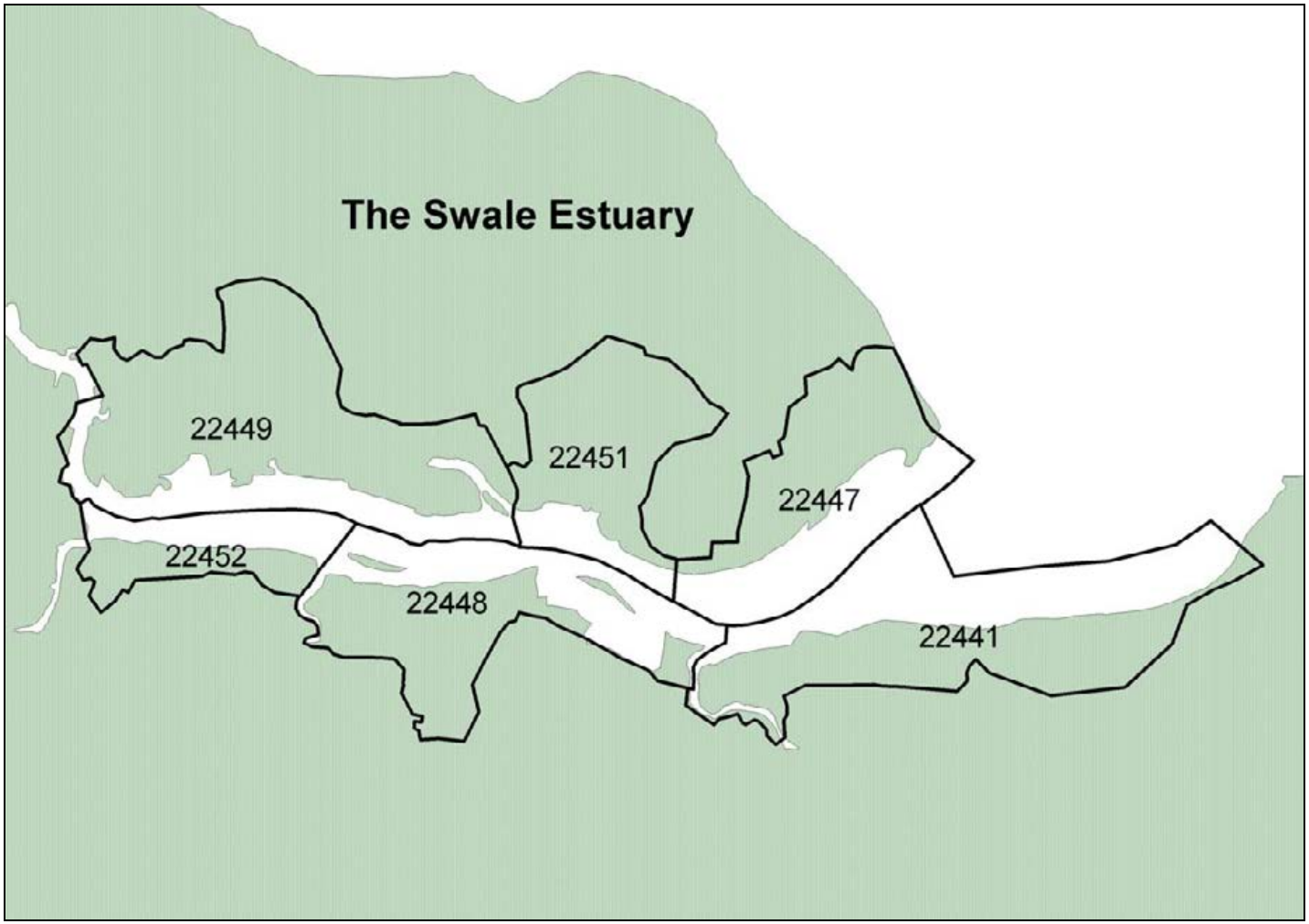
Appendix 1 WeBS Core Count and Low Tide Count sector information.

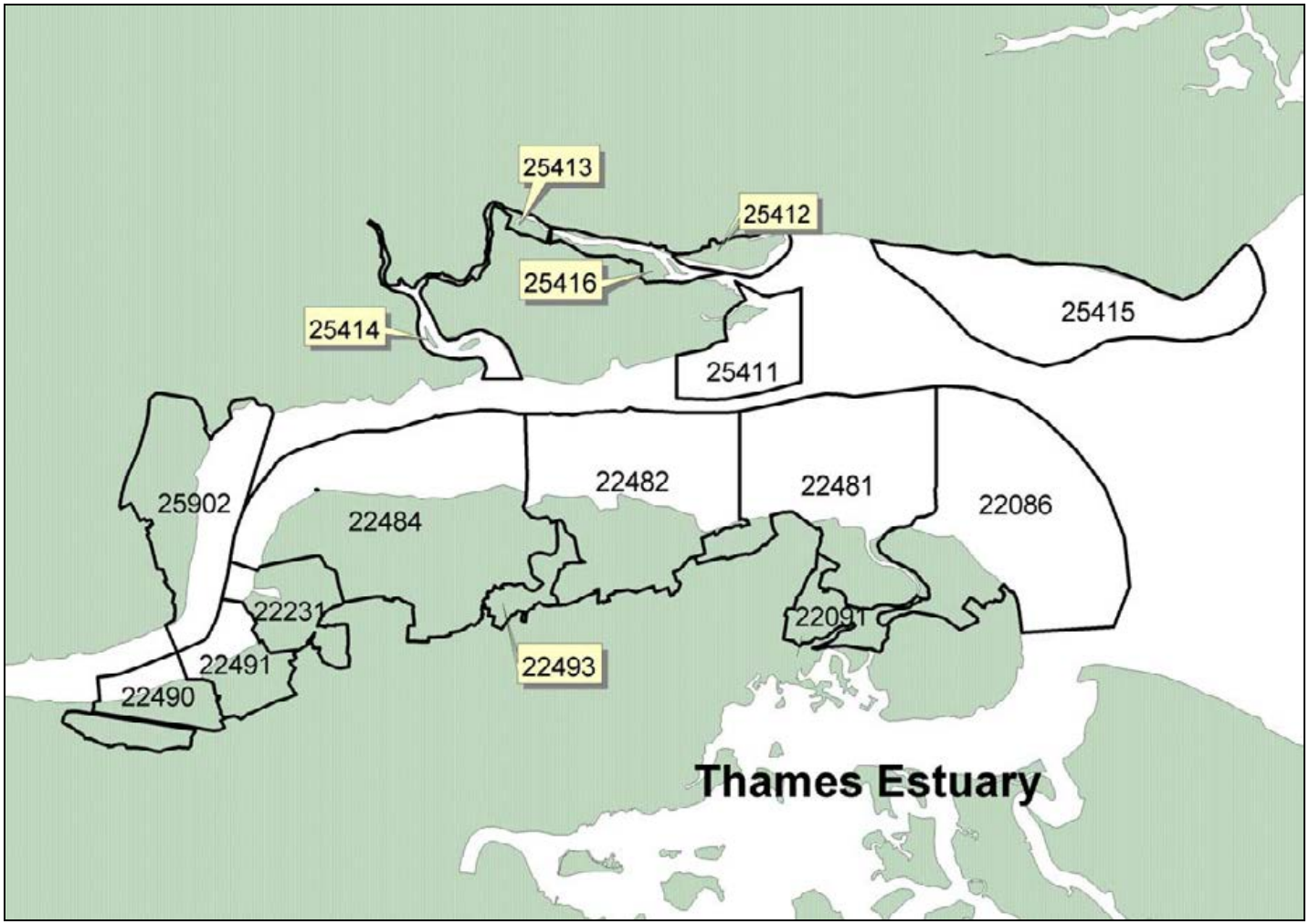
Appendix 1.1 Core Count sectors.



Appendix 1.1.1 Map of WeBS Core Count sectors on the Medway Estuary.



Appendix 1.1.2 Map of WeBS Core Count sectors on the Swale Estuary.



Appendix 1.1.3 Map of WeBS Core Count sectors on the Thames Estuary.

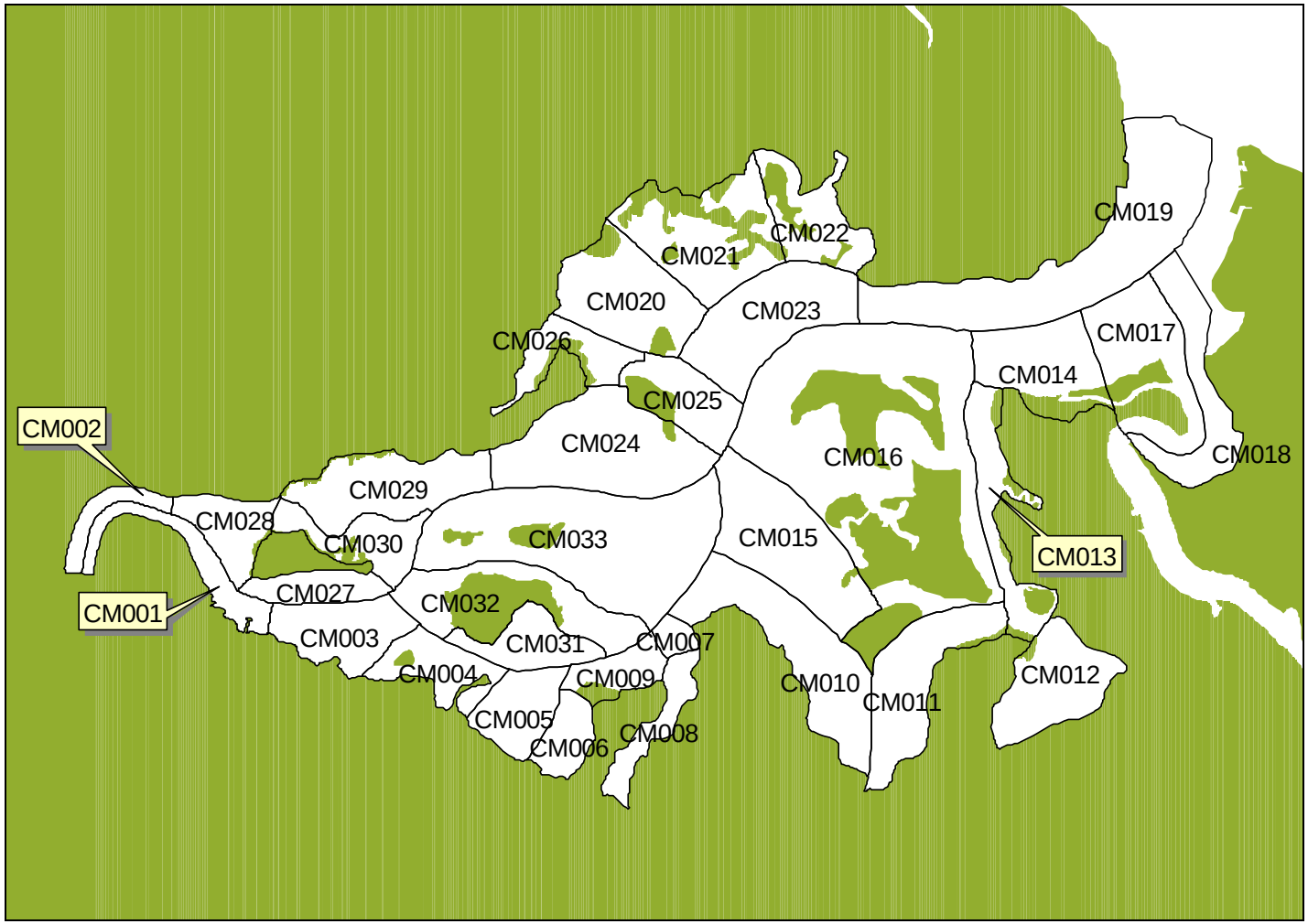
Appendix 1.1.4 Nominal labels of WeBS Core Count sectors and notes on relevant sub-sectors.

NWC Code	Estuary	WeBS Sector Name	Notes
22461	Medway	M2-Rochester Bridge	
22462	Medway	Rochester Bridge-Chatham Maritime	
22463	Medway	Chatham Maritime	
22967	Medway	Hoo and Nor and Bishop and Copperhouse Marshes	Comprises Bishop Islands, Copperhouse Bay, Fry Island, Hoo Marsh and Nor Marsh RSPB Reserve
22972	Medway	Kingsnorth	Comprises Hoo Marsh, Kingsnorth Power Station and Oakham & Downhead
22973	Medway	Stoke Saltings and Ooze	
22974	Medway	Motney and Otterham Creek	Comprises Bloors Wharf, Motney Saltings and Creek, Motney Sewage Treatment Works, Otterham Creek and Riverside Country Park
22978	Medway	Ham Green	Comprises Ham Green, Ham Green & Twinney Offshore, Horsham Marsh and Twinney
22960	Medway	Deadman's Island	
22961	Medway	Chetney Marshes	
22963	Medway	Barksore and Funton	Comprises Barksore Marsh, Funton and Twinney Creek
22964	Medway	Burntwick and Greenborough and Slayhills	Comprises Burntwick Island, and Greenborough and Slayhills
22085	Medway	South Grain	Comprises Grain Industrial, House Fleet, Mosco Pool and South Grain Offshore
22441	Swale	Faversham to Whitstable	Comprises Graveney to Whitstable and South Swale NNR
22447	Swale	Shellness and Harty Marshes	
22448	Swale	Conyer to Oare	Comprises Conyer to Luddenham Gut, Luddenham Gut to Faversham Creek, and Faversham to Conyer
22449	Swale	Elmley Marshes	
22451	Swale	Capel Fleet	
22452	Swale	Murston to Conyer	
22086	Thames	North Grain	
22091	Thames	Stoke Fleet and Marshes	
22231	Thames	Cliffe Pits and Pools	
22481	Thames	Yantlet and Allhallows	
22482	Thames	St Mary's Marsh and Coombe Bay	
22484	Thames	Cliffe and Cooling Marshes	
22490	Thames	Shorne and Filborough Marshes	
22491	Thames	Higham Marsh and Bight	
22493	Thames	Northward Hill RSPB Reserve	
25411	Thames	Canvey Point	
25412	Thames	Leigh Marsh and Two Tree Island	

Appendix 1.1.4 Continued.

NWC Code	Estuary	WeBS Sector Name	Notes
25413	Thames	Easthaven Creek	
25414	Thames	Vange and Holehaven Creek	
25415	Thames	Southend Seafront	
25416	Thames	Benfleet Creek	
25902	Thames	Tilbury to Mucking including Mucking Gravel Pits	

Appendix 1.2 Low Tide Count sectors.



Appendix 1.2.1 Map of WeBS Low Tide Count sectors on the Medway Estuary.

Sector	1996/97	2004/05
CM001	✓	
CM002	✓	
CM003	✓	✓
CM004	✓	
CM005	✓	
CM006	✓	
CM007	✓	
CM008	✓	
CM009	✓	
CM010	✓	✓
CM011	✓	✓
CM012	✓	✓
CM013	✓	✓
CM014	✓	✓
CM015	✓	✓
CM016	✓	✓
CM017	✓	✓
CM018	✓	
CM019	✓	✓
CM020	✓	✓
CM021	✓	✓
CM022	✓	✓
CM023	✓	✓
CM024	✓	
CM025	✓	
CM026	✓	
CM027	✓	
CM028	✓	
CM029	✓	
CM030	✓	
CM031	✓	
CM032	✓	
CM033	✓	✓

Appendix 1.2.2 WeBS Low Tide Sectors counted in two winters of survey.